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MANNED ORBITAL SYSTEMS CONCEPTS STUDY

BOOK 2 - REQUIREMENTS FOR EXTENDED-DURATION MISSIONS

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FOREWORD

The basic MOSC Study encompassed a 9-month effort which examined the requirements for and established the definition of a cost-effective orbital facility concept capable of supporting extended manned operations in Earth orbit beyond those visualized for the 7- to 30-day Shuttle/Spacelab system. The study activity was organized into the following four tasks:

Task 1 Requirements Derivation

Task 2 Concepts Identification

Task 3 System Analysis and Definition

Task 4 Programmatics

In Task 1 the payload and mission requirements were examined for manned orbital systems with operational capabilities beyond those presently planned for the Shuttle/Spacelab program. These research activities were translated into characteristics of representative grouped payloads, including physical and operational parameters. The manned approach to research implementation was emphasized, as well as the lessons learned from previous Apollo and Skylab experience.

The second study task originally centered about the identification and definition of attached and free-flyer manned concepts to satisfy the requirements evolved from Task 1. Based upon the material presented in the first formal briefing, the study was redirected to conclude work on the attached mode of operation and concentrate the remaining effort on free-flying concepts.

Task 3 provided detailed definition of the baseline MOSC concept and the critical subsystem areas to a level required for subsequent programmatic analyses.

Task 4 developed project cost and schedule milestones related to the baseline concept in order to provide NASA with data useful for long-range planning activities and program analyses.

The study results are reported in four books. Book 1 presents an executive summary and overview of the study; Book 2 describes the derivation of requirements; Book 3 describes configuration development; and Book 4 describes the programmatic analyses.

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Section 1
INTRODUCTION

The decision makers within the National Aeronautics and Space Administration (NASA) responsible for determining objectives, allocating funds, and developing schedules and mission plans to attain this nation's long-range space goals are faced with a significant challenge. On the one hand, long-range programs of national and international scope require considerable lead time in fiscal commitments for the timely development of the systems and equipment needed to implement them. On the other hand, in scientific investigations and the exploration of new environments, unexpected events sometimes contribute more significantly to the advancement of knowledge than do planned ones; these unexpected developments can significantly impact system design and mission operations and the attendant program costs. The ability to respond rapidly to new discoveries or new mission potentials requires planning and the development of system concepts that are sufficiently detailed for long-range programming yet are adaptable to changing constraints and priorities based upon changing scientific, political, economic, social, and technological factors.

In order to provide essential data needed by NASA in its long-range program planning, the Manned Orbital Systems Concepts (MOSC) Study has attempted to define, evaluate, and compare concepts for manned orbital systems that provide extended experiment mission capabilities in space, flexibility of operation, and growth potential. Extended capabilities include flight durations longer than the 7- to 30-day periods available on Spacelab, free-flying modes of operation which are autonomous to the Orbiter, disturbance-free and contamination levels lower than those available with the attached mode, and capabilities to support very large payloads that could not be accommodated in the Orbiter's cargo bay. Further, the free-flying mode of operation is inherently more flexible than the attached mode of operation; payloads and

supporting subsystems can be left in orbit and do not necessarily need to be retrieved each time the Orbiter returns to Earth. The extended capabilities are typical of the advantages that a MOSC offers in structuring future and advanced missions.

Extending the available mission periods beyond the current 7- to 30-day limits is desired for future payload programs. For example, longer-duration missions are essential for time-dependent phenomena, such as physiological adaptation and physical growth processes, to be investigated. Furthermore, advantage can be taken of improved efficiency that results from the crew learning to work more effectively with repeated trials and becoming acclimated to the space environment. Longer missions offer potential savings by allowing a less tightly constrained timeline and work schedule, which in turn allows more flexibility to meet expected mission anomalies. Likewise, longer missions permit a given amount of work to be accomplished with fewer flights, thus permitting cost-effective utilization of the STS. Savings could also be expected in ground operations from the reduction in the number and extent of turnarounds, refurbish cycles, and checkout operations. The realization of longer-duration space missions will have significant impact upon the effectiveness, the economies, and the breadth of research opportunities possible.

The key issues to which the MOSC Study addressed itself are as follows:

- The identification of scientific and technological areas which require or can be implemented more cost effectively by extended space flight.
- The delineation and exploitation of man's role in simplifying orbital operations.
- The effective and judicious use of the wealth of available background data, with emphasis on recent Skylab experience.
- The effective use of existing Skylab/Shuttle/Spacelab hardware and technology.
- The establishment of an evolutionary path of concept development that most efficiently proliferates growth and future applications.

- The assurance of man's safety and the enhancement of long-duration mission potential through design for reliability and maintainability.
- The development of credible programmatic assessments of costs, schedules, and supporting research and technology requirements.
- The sensitivity of cost to schedule variations and changes in mission requirements.
- The establishment of a valid and reliable evaluation methodology to select the best MOSC approach.
- The investigation of unique applications of, and new mission potentials for, the concepts.

In order to provide proper perspective and to maintain a sense of proportion in advanced design studies, it is believed helpful to consider in scenario form the alternative courses of action and the objectives which singly or in combination represent potential space futures. Figure 1-1 illustrates such a scenario. In the area of manned space systems specifically, long-term objectives include eventual manned planetary missions, lunar bases, space

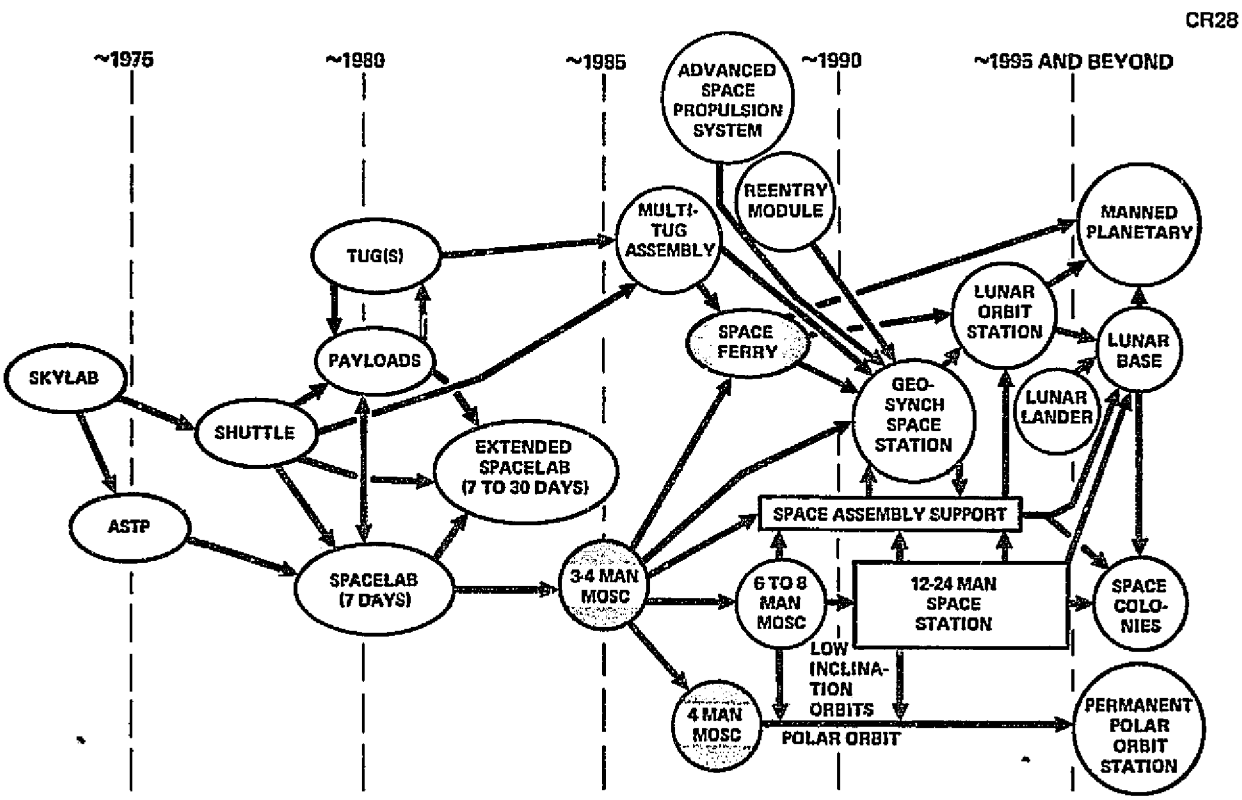

Figure 1-1. Space Systems Scenario

colonization, and permanent Earth-orbital space stations, including facilities in polar and geosynchronous orbits. The role of the systems planner is to develop a plan that will lead to these long-term goals in the most expeditious manner, taking into account the real-world constraints and conflicting demands of financial, technological, and manpower resources. The purpose of the MOSC Study is to examine one step in this overall scenario, that of extending the presently projected capability circa 1980 to longer-duration missions through the most effective use of man and his capabilities, and to do this in a logical and cost-effective manner.

The following definitions were developed for use in the MOSC Study and will be followed in the material reported in the following pages. These definitions are believed to reflect the most common usage of the terms as they appear in other NASA-sponsored studies. Other terminology used in the MOSC Study was based on the usage established in Appendix A of ESRO Spacelab Payload Accommodation Handbook, October 1974, ESTEC Reference Number SLP/2104.

1. <u>Flight:</u> That portion of a mission encompassing the period from launch to landing or launch to termination of the active life of a spacecraft.

2. <u>Mission:</u> The programmatic effort involving the performance of a coherent, related set of investigations (experiments) or operations in space to achieve program goals.

3. <u>Payload:</u> A specific complement of instruments, space equipment, support hardware, and/or supplies carried to space to accomplish a discrete activity or part of a mission.

4. <u>Cargo:</u> Everything contained in the Shuttle cargo bay plus other equipment located elsewhere in the Orbiter that is user unique and not carried in the standard baseline Orbiter weight budget.

5. <u>Experiment:</u> An activity, in space, the objective of which is to obtain data on a single physical phenomenon or to perform a single specific limited task.

Altogether, 103 potential payloads were examined to determine the value of extended-capability flights in accomplishing the desired research objectives. Of these 103 payloads, 46 required or could significantly profit from extended stay times in Earth orbit. These 46 payloads were collated in turn into 19 MOSC payload groups based upon the commonality of the scientific objectives and/or application areas, and commonality of system and operational requirements (altitudes, inclinations, environmental perturbations, etc.). The 19 payload groups are summarized in Table 1-1. For each group, the study team identified the requirements which these typical research programs of the future may impose on manned space facilities. The critical facility sizing parameters include crew size, physical accommodations for payload equipment and supplies, and operational characteristics such as flight duration and orbital requirements. These requirements are major determinants of the subsystems that provide the onboard services and resources, such as electrical power, environmental control, propulsion, vehicle stabilization, communications, and data management functions. Likewise, the physical properties of the payloads influence space allocations, services to be provided, and operational considerations such as deployment and pointing requirements, orbital inclination and altitude operating regimes, total STS flight and cargo requirements, and major scheduling factors.

This volume of the final report describes the procedures followed and the analyses conducted in establishing the baseline requirements to be used in the conceptual design of the manned orbital systems concepts.

Section 2 describes the research data base used in the study, Section 3 discusses the role of man in future missions, Section 4 discusses the requirements for extended capability, Section 5 describes the mission/payload concepts, and Section 6 summarizes the preliminary design and operational requirements which should be met by future manned orbital systems.

Table 1-1

MOSC PAYLOAD COMBINATIONS

Payload	Description	Crew Manhours	Weight 1,000 lb (kg) Up	Down	Volume ft^3 (m^3)
C1	IR Astronomy	1,454	31(14)	25(11)	4,500(135)
C2	UV Astronomy	3,845	24(11)	14(6)	1,100(33)
C3	Solar Observations	4,187	15(7)	14(6)	1,000(30)
C4	Space Sciences 1	2,070	17(8)	15(7)	2,700(81)
C5	Space Sciences 2	1,608	16(7)	12(5)	2,200(66)
C6	AMPS/Earth Science	3,280	24(11)	14(6)	1,900(57)
C7	Space Technology	884	26(12)	17(8)	2,300(69)
C8	Cloud Physics/Technology	882	15(7)	13(6)	2,000(60)
C9	Earth Science 1	851	25(11)	24(11)	6,100(183)
C10	Earth Science 2	690	26(12)	26(12)	6,000(180)
C11	High-Energy Astronomy/ Technology	1,118	20(9)	20(9)	1,200(36)
C12	Life Science/Materials Technology 1	8,289	100(45)	66(30)	13,300(399)
C13	Life Science/Materials Technology 2	4,039	81(36)	60(27)	10,600(318)
C14	IR/UV Astronomy	1,427	45(20)	17(8)	2,000(60)
C15	UV Astronomy, Advanced	585	24(11)	16(7)	1,000(30)
C16	Cosmic Ray Lab	5,800	50(23)	37(17)	5,600(168)
C17	LD Life Science Lab	23,200	39(18)	34(15)	2,600(78)
C18	Advanced Technology	493	8(4)	7(3)	1,600(48)
C19	Space Manufacturing	11,000	7(3)	6(3)	200(6)

Section 2
RESEARCH DATA BASE

The MDAC team was provided at the outset of the study with sortie payload descriptions and references listing 99 payloads to be considered as potential candidates for MOSC. The sources of these descriptions in the listing included (1) SSPDA Sortie Payloads Level A documents and Level B documents, dated 1974, (2) a preliminary Level A description of the Life Sciences Long-Duration Laboratory, (3) the referenced Blue Book Cosmic Ray Physics Laboratory FPE, and (4) a referenced 1973 Level A description of the 4000-pound version of the Communications/Navigation Shuttle sortie laboratory. (As a point in clarity, no SSPDA Automated Payloads were considered.) In addition, and as will be discussed later, four in-space manufacturing payloads were added to the list, making a total of 103 payloads considered. Preliminary descriptions of these four potentially high-payoff space production activities are further detailed in Appendix A. A listing of these 103 payloads together with the sources of the data is presented in Table 2-1.

To serve as a technical management tool in the assessment, analysis, and comprehension of the characteristics and properties of each payload listed in Table 2-1, a tabular summary (see Appendix A) was prepared by the study team. In the initial analysis, that is before the four space production payloads were introduced, 99 payloads were investigated. For each of these 99 payloads some 120 factors were analyzed, as described in the appendix. These were of use in (1) analyzing the payload for desirability or advantages of extended capability and/or (2) determining the individual payload requirements which have both a physical and operational impact on the carrier space research facility. The data and factors analyzed were derived from SSPDA data or are extrapolations from these data together with additional information derived from other sources.

Table 2-1 (Page 1 of 3)
SORTIE PAYLOADS INVESTIGATED

				Data Source			
				SSPDA Level A, July 74	SSPDA Level B, July 74	SSPDA Level B, October 73	NHB 7150.1, Vol III January 71 (Blue Book)
		ASTRONOMY					
*	✓	AS-01-S	1.5-m Cryogenically Cooled IR Telescope [1]	✓	✓		
*	✓	AS-03-S	Deep Sky UV Survey Telescope [2]	✓	✓		
*	✓	AS-04-S	1-m Diffraction-Limited UV Optical Telescope [3]	✓	✓		
		AS-05-S	Very-Wide-Field Galactic Camera	✓	✓		
		AS-06-S	Calibration of Astronomical Fluxes	✓			
		AS-07-S	Cometary Simulation	✓		✓	
*		AS-08-S	Multipurpose 0.5-m Telescope [21]	✓			
		AS-09-S	30-m IR Interferometer	✓		✓	
*		AS-10-S	ADV. XUV Telescope [22]	✓			
		AS-11-S	Polarimetric Experiments	✓			
		AS-12-S	Meteoroid Simulation	✓			
*		AS-13-S	Solar Variation Photometer [23]	✓			
		AS-14-S	1.0-m Uncooled IR Telescope	✓			
*	✓	AS-15-S	3.0-m Ambient Temperature IR Telescope [4]	✓	✓		
		AS-18-S	1.5-km IR Interferometer	✓		✓	
*		AS-19-S	Selected Area Deep Sky Survey Telescope [24]	✓			
		AS-20-S	2.5-m Cryogenically Cooled IR Telescope	✓		✓	
*		AS-31-S	Combined AS-01, -03, -04, -05-S 25	✓			
		AS-41-S	Schwartzschild Camera	✓			
		AS-42-S	Far UV Electronographic Schmidt Camera/Spectrograph	✓			
		AS-43-S	UCB Black Brant Payload	✓			
		AS-44-S	XUV Concentrator/Detector	✓			
		AS-45-S	Proportional Counter Array	✓			
		AS-46-S	Wisconsin UV Photometry Experiment	✓			
		AS-47-S	Attached Far IR Spectrometer	✓			
		AS-48-S	Aries/Shuttle UV Telescope	✓			
		AS-49-S	First UCB Black Brant Payload	✓			
		AS-50-S	Combined UV/XUV Measurements (AS-04-S, 10-S)	✓			
		AS-51-S	Combined IR Payload (AS-01-S, 15-S)	✓			
*		AS-54-S	Combined UV Payload (AS-03-S, 04-S) [26]	✓			
		AS-61-S	Attached Far IR Photometer (Wide FOV)	✓			
		AS-62-S	Cosmic Background Anisotropy	✓			
*		AS-01-R	LST Revisit [27]	✓			
		HIGH-ENERGY ASTROPHYSICS					
		HE-11-S	X-ray Angular Structure	✓	✓		
		HE-12-S	High-Inclination Cosmic-Ray Survey	✓			
		HE-13-S	X-ray/Gamma-Ray Pallet	✓			
*		HE-14-S	Gamma-Ray Pallet [28]	✓			
		HE-15-S	Magnetic Spectrometer	✓	✓		
		HE-16-S	High-Energy Gamma-Ray Survey	✓			
		HE-17-S	High-Energy Cosmic-Ray Study	✓			
		HE-18-S	Gamma-Ray Photometric Studies	✓			
*		HE-19-S	Low-Energy X-ray Telescope [29]	✓			
		HE-20-S	High-Resolution X-ray Telescope	✓			
		HE-03-R	Extended X-ray Survey Revisit	✓			
*		HE-11-R	Large High-Energy Observatory D Revisit [30]	✓			
*	✓	HE-X-S	Cosmic-Ray Physics Lab FPE [5]	✓			✓

*Payloads identified for extended missions based upon mission model assignments 1984 and beyond.
✓ Payloads proposed for extended missions by MSFC personnel in the science and applications areas.
[ ]- ID No. ref. Table 2-2

Table 2-1 (Page 2 of 3)

SORTIE PAYLOADS INVESTIGATED

				Data Source			
				SSPDA Level A, July 74	SSPDA Level B, July 74	SSPDA Level B, October 73	NHB 7150.1, Vol III January 71 (Blue Book)
		SOLAR PHYSICS					
*	✓	SO-01-S	Dedicated Solar Sortie Mission (DSSM) [6]	✓	✓		
		SO-11-S	Solar Fine-Pointing Payload	✓	✓		
		SO-12-S	ATM Spacelab	✓			
		ATMOSPHERIC AND SPACE PHYSICS					
*	✓	AP-06-S	Atmospheric, Magnetospheric, and Plasmas in Space (AMPS) [7]	✓	✓		
		EARTH OBSERVATIONS					
*	✓	EO-01-S	Zero-G Cloud Physics Laboratory [11]	✓	✓		
*	✓	EO-05-S	Shuttle Imaging Microwave System (SIMS) [12]	✓	✓		
*	✓	EO-06-S	Scanning Spectroradiometer [13]	✓	✓		
*	✓	EO-07-S	Active Optical Scatterometer [14]	✓		✓	
		EARTH AND OCEAN PHYSICS					
*	✓	OP-02-S	Multifrequency Radar Land Imagery [15]	✓	✓		
*	✓	OP-03-S	Multifrequency Dual Polarized Microwave Radiometry [16]	✓	✓		
*	✓	OP-04-S	Microwave Scatterometer [17]	✓	✓		
*	✓	OP-05-S	Multispectral Scanning Imagery [18]	✓	✓		
*	✓	OP-06-S	Combined Laser Experiment [19]	✓	✓		
		SPACE PROCESSING APPLICATIONS					
		SP-01-S	SPA No. 1 - Biological (Manned) (B+C)	✓	✓		
		SP-02-S	SPA No. 2 - Furnace (Manned) (F+C)	✓		✓	
		SP-03-S	SPA No. 3 - Levitation (Manned) (L+C)	✓		✓	
*		SP-04-S	SPA No. 4 - General Purpose (Manned) (G+C) [31]	✓		✓	
*		SP-05-S	SPA No. 5 - Dedicated (Manned) (B+F+L+G+C) [32]	✓			
		SP-12-S	SPA No. 12 - Automated Furnace (FP+CP)	✓			
		SP-13-S	SPA No. 13 - Automated Levitation (LP+CP)	✓			
*	✓	SP-14-S	SPA No. 14 - Manned and Automated (B+G+C+FP+LP) [20]	✓	✓		
*		SP-15-S	SPA No. 15 - Automated Furnace/Levitation (FP+LP+CP) [33]	✓	✓		
*		SP-16-S	SPA No. 16 - Biological/General (Manned) (B+G+C) [34]	✓			
*		SP-19-S	SPA No. 19 - Biological and Automated (B+C+FP+LP) [35]	✓			
		SP-21-S	SPA No. 21 - Minimum Biological (B+C)	✓			
		SP-22-S	SPA No. 22 - Minimum Furnace (Manned) (F+C)	✓			
		SP-23-S	SPA No. 23 - Minimum General (G+C)	✓			
		SP-24-S	SPA No. 24 - Minimum Levitation (Manned) (L+C)	✓			
		SP-X1-S	Production of Surface Acoustic Wave Components	(1)			
		SP-X2-S	Production of High-Ductility Tungsten	(1)			
		SP-X3-S	Separation of Iso-Enzymes	(1)			
		SP-X4-S	Solar Furnace for Production of Semiconductor Silicon Ribbon	(1)			

(1) Special preliminary data sheet.
[ ] - ID No. ref. Table 2-2

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Table 2-1 (Page 3 of 3)

SORTIE PAYLOADS INVESTIGATED

				Data Source			
				SSPDA Level A, July 74	SSPDA Level B, July 74	SSPDA Level B, October 73	NHB 7150, 1, Vol III January 71 (Blue Book)
		LIFE SCIENCES					
*		LS-04-S	Free-Flying Teleoperator [36]	✓	✓		
*		LS-09-S	Life Sciences Shuttle Laboratory [37]	✓	✓		
*		LS-10-S	Life Sciences Carry-on Laboratories [38]	✓	✓		
*	✓	LS-X-S	Life Sciences Long-Duration Laboratory [8]	(1)			
		SPACE TECHNOLOGY					
*		ST-04-S	Wall-less Chemistry + Molecular Beam (Facility No. 1) [39]	✓		✓	
*		ST-05-S	Superfluid He + Particle/Drop Positioning (Facility No. 2) [40]	✓		✓	
*		ST-06-S	Fluid Physics + Heat Transfer (Facility No. 3) [41]	✓		✓	
		ST-07-S	Neutral Beam Physics (Facil. No. 4)	✓		✓	
*		ST-08-S	Integrated Real-Time Contamination Monitor [42]	✓	✓		
		ST-09-S	Controlled Contamination Release	✓		✓	
		ST-11-S	Laser Information/Data Transmission	✓		✓	
		ST-12-S	Entry Technology	✓			
		ST-13-S	Wake Shield Investigation	✓			
*	✓	ST-21-S	ATL P/L No. 2 (Module + Pallet) [9]	✓	✓		
*		ST-22-S	ATL P/L No. 3 (Module + Pallet) [43]	✓	✓		
*		ST-23-S	ATL P/L No. 5 (Pallet Only) [44]	✓	✓		
		COMMUNICATIONS AND NAVIGATION					
*	✓	CN-02-S	Comm/Nav Shuttle Sortie Lab (4000-lb version) [10]			✓	
*		CN-04-S	Terrestrial Sources of Noise + Interference [45]	✓	✓		
		CN-05-S	Laser Communication Experimentation	✓	✓		
*		CN-06-S	Communication Relay Tests [46]	✓			
		CN-07-S	Large Reflector Deployment	✓			
		CN-08-S	Open Traveling Wave Tube	✓			
		CN-11-S	Stars and Pads Experimentation	✓			
		CN-12-S	Interferometric Navigation and Surveillance Techniques	✓			
		CN-13-S	Shuttle Navigation Via Geosynchronous Satellite	✓			

(1) Special preliminary data sheet.
[ ] - ID No. ref. Table 2-2

The major categories of the payload data are as follows:

1. Mission model emphasis (number of assigned flights in 1984 and post-1984 period).
2. Payload type (accommodation mode — module, pallet, module/pallet, carry-on).
3. Orbital parameters (apogee, perigee, inclination, launch window, etc.).
4. Crew requirements (number of personnel, manhours, extravehicular activity requirements, skills, etc.).
5. Physical characteristics (volume, weight, power, consumables, additional items of equipment, spares, etc.).
6. Viewing and pointing requirements.
7. Environmental requirements.
8. Experiment data requirements and characteristics.

Information has been extracted from the source documents, which in general described requirements based upon payload characteristics for missions of 7 days' duration. These 7-day figures were extrapolated when feasible to mission times of 30, 60, and 90 days. From this parametric treatment of the data, growth curves were plotted and estimates were made of payload requirements for missions of any duration out to 90 days. This information permitted optional mission periods to be evaluated as well as assessments to be made of payload sensitivities to changes in mission period.

In light of Skylab experience, when flight periods are extended, additional requirements for such items as spare parts, tools, test equipiment, and the like can be expected. This type of information is not included in either the Space Shuttle Payload Description Activity (SSPDA) Level A or Level B descriptions. Therefore criteria were established for each class and category of payload as to the requirements of these items as a function of flight duration. The assumptions leading to the sparing criteria are detailed in Appendix A.

Initial recommended payloads for extended-capability missions were suggested by Marshall Space Flight Center (MSFC) personnel in the science and applications areas as indicated by circled check marks on the left side of Table 2-1. These payloads received primary study emphasis. In addition to

the 20 payloads originally suggested by NASA, the study team identified 26 additional payloads for more detailed analysis. These were payload areas in which the multiple number and frequency of flights in the mission model for the post-1984 calendar period suggested that greater efficiencies of operation and greater scientific value would be achieved by incorporating them into missions of longer duration. Table 2-2 contains important characteristics of the 20 NASA-recommended and the 26 MDAC-recommended payloads.

Those payloads tentatively identified for extended capabilities are distinguished by an asterisk (*) in Table 2-1. As seen from the table, there are Level A or equivalent descriptions available for all but 15 of the payloads marked by the asterisk. Because the SSPDA sources are generally lacking in requirements for flight durations in excess of 7 days (a few are detailed for 30-day flights), the study relied on discussions with NASA payload discipline specialists, Skylab experience and other data sources to develop longer-duration research requirements. Alternative methods of "packaging" these payloads within missions and flights were examined. The 20 payloads recommended by the MSFC Payloads Panel provided the initial point of departure for this payload packaging activity. A statistical analysis of the 20 payloads described in Table 2-2 reveals the following:

a. The Cosmic Ray Physics Laboratory (Blue Book derived) and the Long-Duration Life Science Laboratory (special SSPDA) represent uniquely large and oversized facility requirements when compared with the other 18 payloads. Therefore, it is proposed to treat these two payloads as special cases (potentially classified as dedicated laboratory modules) as the study progresses.
b. The remainder of the 18 payloads requires an aggregate of 25,243 manhours of orbital support. This represents, on the average, a workload of 1,402 manhours required to complete a typical payload protocol.
c. The average total weight of the complement of instruments, space equipment, support hardware and/or supplies making up each of the 18 payloads is presented by experiment discipline in Figure 2-1. This figure also presents an aggregate average of all 18 payloads as a function of mission duration.

Table 2-2

CHARACTERISTICS OF 46 PAYLOADS

			Payload Physical Characteristics				Orbital Parameters	
ID No.	No. of 7-Day Flights	Total Man-Hours	Volume 100 ft^3 (m^3)	Weight 100 lb (kg)	Average Power watts	Energy kWh	Inclination deg	Altitude nmi (km)
NASA PANEL RECOMMENDATIONS								
1	8	1,403	8 (23)	73 (3,296)	944	148.0	28	216 (400)
2	6	873	6 (17)	83 (3,774)	992	172.0	28	162 (300)
3	23	4,002	4 (11)	40 (1,836)	400	58.0	28	162 (300)
4	9	765	33 (94)	117 (5,326)	944	148.0	28	216 (400)
5	6	800	56 (160)	330 (15,000)	690	4,990.0	28	200 (370)
6	20	5,000	30 (86)	124 (5,619)	702	63.0	30	189 (350)
7	27	8,424	15 (42)	118 (5,381)	2,525	425.0	28	235 (435)
8	6	1,920	9 (25)	462 (21,000)	8,000	1,346.0	28	108 (200)
9	5	620	12 (34)	30 (1,353)	430	104.0	28	100 (185)
10	8	984	12 (35)	43 (1,955)	2,100	126.0	60	200 (370)
11	5	177	3 (9)	18 (797)	400	2.0	28	108 (200)
12	12	1,028	57 (164)	164 (7,432)	1,880	231.0	70	235 (435)
13	13	209	1 (3)	11 (520)	914	19.0	65	183 (339)
14	12	318	0.3 (1)	10 (443)	264	32.0	90	100 (185)
15	11	303	4 (10)	32 (1,470)	2,192	197.0	57	108 (200)
16	7	193	1 (2)	14 (633)	350	18.0	57	108 (200)
17	6	225	0.3 (1)	9 (388)	475	20.0	90	108 (200)
18	11	303	4 (10)	32 (1,470)	2,192	197.0	90	108 (200)
19	3	182	1 (2)	8 (343)	560	51.0	57	108 (200)
20	8	234	32 (90)	140 (6,365)	10,000	1,130.0	28	108 (200)
MDAC STUDY TEAM RECOMMENDATIONS								
21	96	816	0.3 (1)	12 (554)	100	14.0	28	255 (473)
22	6	936	2 (5)	9 (426)	400	62.0	28	248 (460)
23	192	1,248	0.04 (0.1)	0.4 (20)	20	0.3	28	100 (185)
24	10	720	3 (9)	22 (1,000)	400	58.0	28	216 (400)
25	15	2,340	18 (50)	176 (8,009)	2,429	371.0	28	162 (300)
26	5	780	10 (28)	154 (7,017)	1,392	201.0	28	162 (300)
27	7	672	12 (35)	97 (4,400)	1,200	115.0	28	281 (520)
28	5	65	6 (18)	103 (4,687)	360	56.0	28	120 (223)
29	5	390	1 (4)	40 (1,814)	356	56.0	22	120 (223)
30	5	480	13 (38)	97 (4,400)	1,200	1,400.0	15	250 (463)
31	8	82	1 (3)	51 (2,325)	2,400	260.0	28	100 (185)
32	8	527	4 (10)	156 (7,085)	4,800	1,130.0	28	100 (185)
33	8	48	0.1 (0.3)	108 (4,907)	3,600	860.0	28	100 (185)
34	8	186	2 (7)	69 (3,119)	2,400	360.0	28	100 (185)
35	8	152	2 (5)	127 (5,793)	3,600	970.0	28	100 (185)
36	8	72	1 (3)	8 (345)	445	4.0	28	100 (185)
37	20	21,600	1 (2)	56 (2,529)	2,507	358.0	28	200 (370)
38	16	224	16 (46)	6 (261)	756	50.0	28	100 (185)
39	16	544	2 (5)	14 (643)	497	16.0	55	270 (500)
40	16	544	5 (14)	7 (330)	453	16.0	28	100 (185)
41	16	704	1 (4)	14 (622)	304	11.0	28	100 (185)
42	50	0	0.04 (0.1)	1 (53)	147	26.0	28	100 (185)
43	5	606	11 (30)	1 (35)	574	98.0	28	100 (185)
44	6	782	15 (44)	71 (3,228)	2,100	242.0	60	200 (370)
45	5	861	3 (8)	6 (289)	1,058	17.0	55	200 (370)
46	5	781	1 (4)	15 (678)	1,460	20.0	55	200 (370)

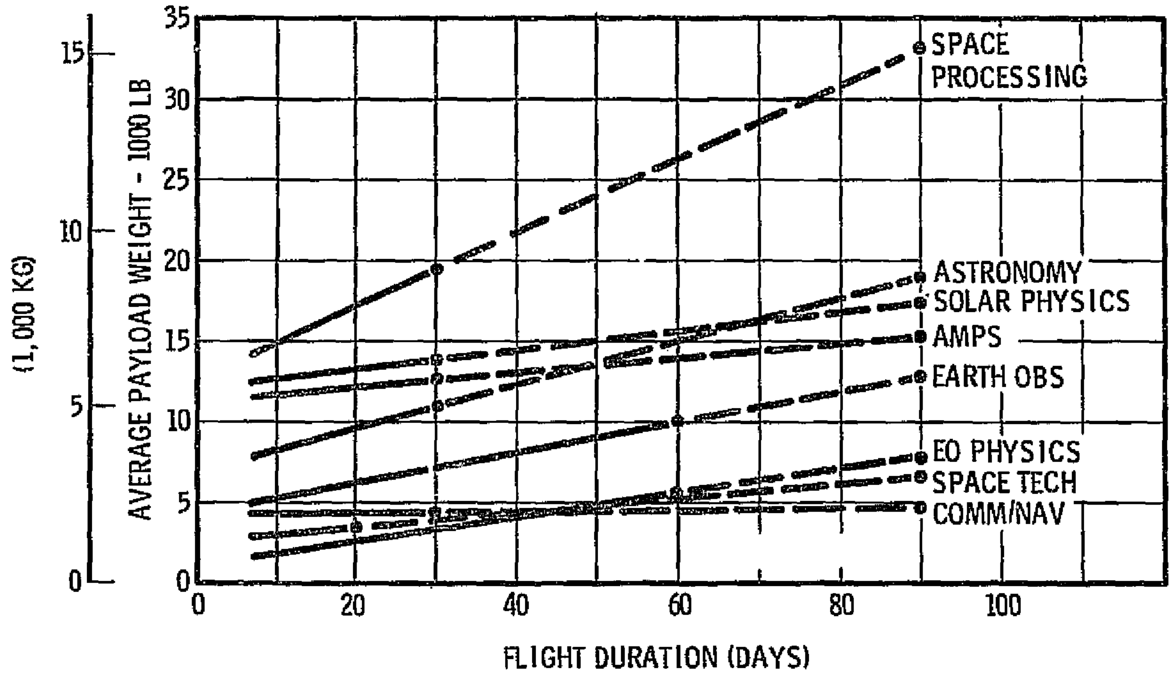

Figure 2-1. Weight Summary — 18 Payloads

When extrapolating Spacelab payload requirements for extended missions, the point of origin was taken from the SSPDA 7-day mission requirements. Figure 2-1 shows a rapid increase in payload weights of Space Processing Payloads. This is due to the requirements for the consumables required to support the processing operations. These consumables are of two types: (1) consumables used directly in the operations, such as electrolytes, buffer solutions, inert gases, and dewars for freezing specimens; and (2) LOX, LH_2, fuel cells, water containers, inverters, and cooling systems, used for power generation, power conditioning, and heat dissipation.

As a typical example, using the SSPDA space processing payload, SP-14-S, 1,050 pounds of consumables are required to support a 7-day flight of which 66 pounds are electrolytes and buffer solutions; the remaining weight is composed of power-related equipment for generation, conditioning, and heat dissipation. Using the MOSC ground rules that two days are not usable (one day up and one day down), this relates to a consumable requirement of

210 pounds/day of operation. Extrapolating this data out to 30-, 60-, and 90-day flights (28, 58, and 88 operational days), the following consumable requirements are obtained:

30 days	60 days	90 days
5, 880 lb (2, 671 kg)	12, 175 lb (5, 533 kg)	18, 470 lb (8, 395 kg)

Spares requirements necessary to support the payload during extended operations were identified as follows:

30 days	60 days	90 days
280 lb (127 kg)	700 lb (318 kg)	1, 400 lb (637 kg)

These weight requirements are then added to the basic payload equipment weight of 12, 950 lb (5, 888 kg), resulting in the following total payload weights:

	30 days	60 days	90 days
Equipment	12, 950 (5, 888)	12, 950 (5, 888)	12, 950 (5, 888)
Consumables	5, 880 (2, 671)	12, 175 (5, 533)	18, 470 (8, 395)
Spares	280 (127)	700 (318)	1, 400 (637)
Total	19, 110 lb (8, 686 kg)	25, 825 lb (11, 739 kg)	32, 820 lb (14, 920 kg)

The daily requirement for data records (i. e., film, magnetic tape, log books) has been estimated using factors derived from Skylab experience and described in Appendix A and has been included. For example, film requirements considered not only the raw film stock but also included film spools, reels, cassettes, and storage containers. Similar methods were used to estimate extended magnetic tape requirements and other data documents.

In many cases the volumetric and weight estimates of these records appear to be excessive. In these cases, the payloads were flagged for further analysis and review. Usage factors determined from Skylab experience have allowances for storage containers and associated protective devices.

Section 3
ROLES AND REQUIREMENTS FOR MAN IN FUTURE SPACE MISSIONS

An important factor to consider in future program planning is the establishment of the requirement for man in fugure space missions, and a definition of his roles and relationships in all areas of investigation. The results and first-hand experience obtained from the conduct of the Apollo and Skylab Programs provide considerable insight in this regard. Table 3-1 lists a workable breakdown of specific crew functions patterned after manned spaceflight experience.

Table 3-1
CREW/TASK FUNCTIONS

Experiment Activities and Operations	(Act as subject, experimenter; evaluate results, extravehicular activities, interfacing and coordinating with ground and other space operations.)
Transfer Operations	(Unstow/stow and relocate equipment and materials.)
Maintenance and Repair	(Perform scheduled and unscheduled maintenance, troubleshooting, repair/test/checkout.)
Data/Communications	(Control configuration of voice, teletype and communications command set, record voice/data/video, process data, edit, reload film and tape machines, log book entries, personnel conversations and communications with ground.)
Extravehicular Activities (Vehicle Oriented)	(Configure equipment, perform maintenance, service expendables, control remote manipulators.)
Housekeeping	(Swab, wipe and vacuum, waste collection and disposal.)
Station-Keeping and Operation	(Station activation, subsystem and equipment checkout; unstowing and stowing of apparatus, accessories and supplies; removal of protective devices.)

Table 3-1 (Continued)
CREW/TASK FUNCTIONS

Personal Support	(Eat, sleep, personal hygiene, relaxation and recreation.)
Emergency Operations	(Abort procedures, restoration activities.)
General	(Planning and redirection activities, mission control.)

In examining the requirements payloads place upon the carrier both in terms of operations and in terms of services, it was instructive to examine the influence the crew could have on establishing service limits both in terms of constraints and in terms of additional capabilities that they provide to the overall facility. Crew influence on mission operations and system services is discussed in the remainder of this report section.

3.1 FUNCTIONAL CAPABILITIES

In manned operations, the crewman plays the primary role. The system must be designed in a manner that permits man to utilize his strong points, such as manipulative skills and judgmental capabilities, and the machine should be assigned to tasks it can do better than man. Typically the machine can perform routine or repetitive functions to an advantage. It is in the areas of performing equipment servicing or unscheduled maintenance functions and dealing with unforeseen events that man is clearly superior to a machine. An important consideration in the design of any manned system should be to ensure that the equipment is designed so as to allow manned access for servicing.

As an example, Skylab estimates indicated that a manual deployment mode for the solar arrays would have produced a 15 percent weight saving in that subsystem. The relocation of power cables on a routine basis to service appropriate apparatus represents an example of where crewmen could play a contributary role in the power distribution system, thereby saving system weight and complexity. The presence of the crewman may permit the use of

a simpler and lighter heat rejection system through the installation of temporary systems to accommodate periodic or transient loads above normal. These examples reinforce the argument for routine as well as one-time-only functions performed manually to replace otherwise complicated automatic functions. In the area of data management and communications, the crewman plays the major role. Besides his presence allowing a simpler system, such as patch panels and plug-in components versus automatic switching, he provides the discretionary intelligence valve judgment in terms of what data is to be handled, how it is channeled and processed, and where it is routed. A crewman can initiate or suspend communications or data management functions as required to better use the capacity of the system as operational demands may dictate. Similar benefits may be realized on other systems.

On Skylab, for example, the crew performed servicing operations that were never originally planned or intended to be done in orbit. Leaks in the airlock module cooling loops resulted in a condition where Coolanol fluid had to be added.

If service ports had been provided in the system, it would have been a simple matter to replace the fluid. As it was, the crew had to install a saddle clamp and puncture a line in order to add Coolanol to the system. This potentially important role of the flight crew on a space vehicle is typified by the comments, general impressions, attitude, and behavior of the first Skylab crew, who are quoted as stating, "We can fix anything, given the proper tools, in space that we can fix on the ground." The experience by all three crews demonstrated clearly that man is the key link in enhancing mission success by retaining, or restoring to service, critical functions. To do this the man must have access in both extravehicular (EVA) and intravehicular (IVA) operations.

One of the biggest problems in the Skylab EVA repair operations was the lack of EVA restraint devices. One of the very important lessons learned from Skylab about EVA operations was that the crew needed the ability to get to any place on the outside of the vehicle for repair jobs. An important ground

rule for any future manned system would be that the crewmen have equipment and suitable restraint and mobility aids to go anywhere on the interior or exterior of the vehicle while in orbit. Because EVA may still prove costly in terms of manhours and effort expended, if constant volume suits are not operational by the 1980's the use of remote manipulators that could bring equipments to airlocks or to mounting provisions in the cargo bay must be considered.

Future manned systems must be designed to maximize the potential for the crewmen to perform troubleshooting and maintenance. As an example, systems should not be designed with fasteners in inaccessible areas which would preclude on-orbit maintenance actions by the crewman.

One of the strongest arguments for the Shuttle-type operations is the potential economies possible by reusing equipment on succeeding flights. To achieve this potential saving, particularly in free-flying concepts, the crew will identify and implement the return of modules for repair. There are many implications in such a design approach that involve the man in terms of how the system is to be tested, how the systems are to be built to allow return of modules for refurbishment, and the size and stowage provisions of the modules aborad the return vehicle. All of these factors must be considered in the total system design if the optimal usage is to be made of the space crew.

In the area of on-orbit improvisation and modifications, the crewman offers some rather distinct advantages. On the Skylab, the crewmen were required to drastically correct the heat balance of the workshop by erection of makeshift thermal shields. Later in the mission, the Skylab crews restored the malfunctioning airlock module coolant loop to service by resupplying the cooling fluid.

Man's sense of sight and visual perception is a valuable attribute which cannot be duplicated in automated equipment. Viewports and other visual capabilities must be provided for certain roles such as the overall control of

orbital and vehicle orientation and maneuvering. The visual inputs can be supplied either by having the remote sensors portray appropriate information on visual displays or by having the pilot positioned so that he can see directly through viewports particularly in the close-in maneuvering (for example, docking).

In both the Apollo Telescope Mount and the Earth Resources Experiment Package Payload on Skylab, the crewmen proved invaluable in assisting and directing the pointing capability of both these experiments. The crewmen greatly enhanced the quality of the data retrieved by being able to observe the overall situation and direct or point the experiment at the areas of interest. It is in this area of making selective executive decisions that man's role is irreplaceable.

3.2 WORKING AND LIVING VOLUMES

Crew size is important in sizing the vehicle because of the necessity to have a usable volume sufficient to accommodate the crew and provide a place for them to perform their work. On Skylab it was found that the space limitations that a man experiences here on Earth due to gravity did not necessarily apply in orbit. In the debriefings, all crewmen agreed that zero gravity will allow the designer of an orbital system more freedom in selecting volumes and weights for the crewmen to manipulate. For example, the large (in excess of 6 ft^3 and over 250 pounds in weight) food lockers were very readily relocated in zero gravity by one crewman working alone as compared to four men required on the ground. One crewman made the statement that it would have been feasible in space to relocate an object the size of the film vault. (The Skylab vault was in excess of 12 ft^3 and weighed approximately 3,000 pounds.) The lessons learned can be directed towards designs and configurations that allow for mechanically unaided manual relocation of relatively large and dense components (250 to 300 lb/ft^3) which would be entirely practical for the crewmen in space.

3.3 CREW SIZE/SKILL MIX/MANPOWER

The crew size and skill mix will be primarily dependent upon the payload demands for operators. With longer missions, a higher degree of cross

training can be expected especially when a diversity of payloads is on board. It can be expected that on longer missions with a proper skills mix and cross training, a relatively small crew complement can provide the needs of the payload.

Skylab crew experience of 84 days in orbit and supporting medical evidence has established the fact that man fully qualified for the mission durations being considered in the MOSC Study. The presence of man will enhance the probability of mission success through his command and control functions and by repairing and restoring critical functions of simpler and lighter systems (as opposed to the weight penalties associated with redundant automated design).

An analysis was made of the crew time requirements necessary to support experimental activities during various flight durations. A number of factors were considered in the analysis and recent Skylab experience was the dominant influence. From the Skylab experience, it can be demonstrated on the average, out of a 24-hour day, a crewman will devote 13-1/2 hours to personal activities (including sleep), 2-1/2 hours to station operation and housekeeping activities, leaving eight hours for experiment activities (see Figure 3-1).

In arriving at these conclusions, an in-depth analysis of the crew performance of the 60-day second Skylab mission (Skylab II) was made. This crew, considered by many persons knowledgeable with manned spaceflight operations to be typical of the best that could be expected, performed the space assignments remarkably well. For each of the crewmen, the as-flown flight plan provided a daily log of their activities. Figure 3-2 is an example of a typical day taken from this flight plan. From the timeline across the top of the log for each crewman, 15 classes of activities can be identified along with the time spent by each crewman for that day in the various classes. These activities are listed in Table 3-2.

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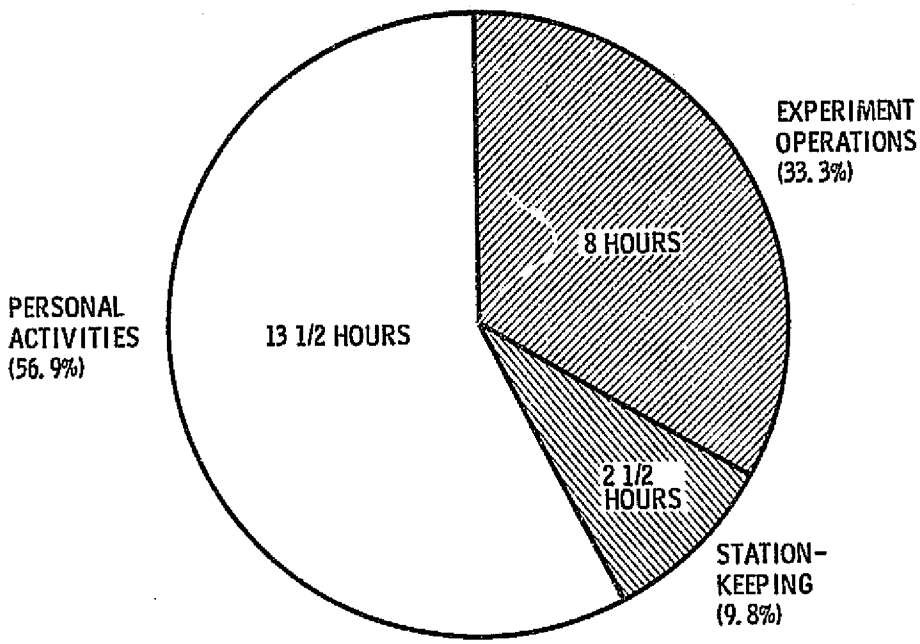

Figure 3-1. Distribution of Crew Time (Skylab II Experience)

A tabular listing of each of the three crewmen's daily activities is included in Appendix B, this data having been taken directly from the Skylab II. As-flown flight plan summary statistics were generated for each crewman as well as for the three crewmen in total. These figures are presented in Tables 3-3 through 3-6.

Figure 3-3 portrays the statistics contained in Table 3-6 on a percentage basis in order to show the relative amount of time spent, on the average, on each activity on a daily basis. The station-keeping segment contains the following activities: 7 maintenance operations, 10 house-keeping and equipment transfers, 14 launch and recovery operations and 15 station activations/ deactivations. In Table 3-7, the 15 activities are gathered into three basic groups as listed in Columns 2, 3, and 4 of the table. Column 2 represents personal duties of the crew accumulating sleep, eating, hygiene, training and rest and relaxation. Column 3 represents experiment operations including Apollo telescope mount time, Earth resources experiment package

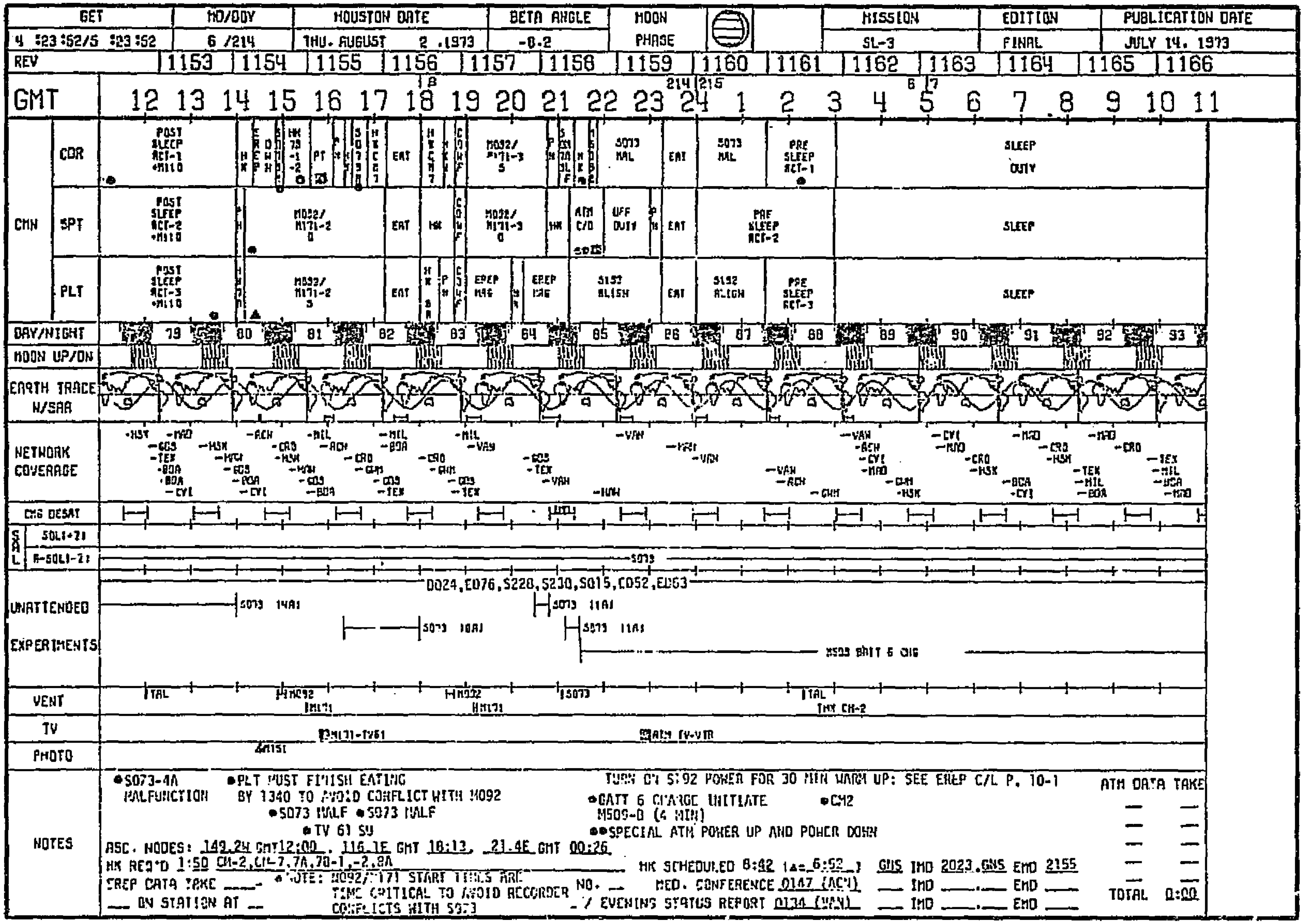

Figure 3-2. Typical Day in Skylab II

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Table 3-2

SKYLAB CREW ACTIVITIES

1 - Sleep	8 - Personal Hygiene
2 - Eating (Includes Food Preparation), Pre- and Post Sleep Periods	9 - Personal Training
3 - Operation of Apollo Telescope Mount	10 - Housekeeping and Equipment Transfer
4 - Operation of Earth Resources Package	11 - Rest and Relaxation
5 - Operation of Corollary Experiments	12 - Student Experiments and TV Operation
6 - Operation of Medical Experiments	13 - Extravehicluar Activities
7 - Maintenance Operations	14 - Launch and Recovery Operations
	15 - Station Activation/Deactivation

Table 3-3

ACTIVITY STATISTICS (HOURS) – SKYLAB II COMMANDER, BEAN

Activity	Mean	Std Dev	Std Err	Max	Min	Range
Sleep	7.88	1.15	0.15	9.70	0.00	9.70
Eat	4.26	1.56	0.20	7.70	1.00	6.70
ATM	2.02	1.76	0.23	6.90	0.00	6.90
EREP	1.40	1.71	0.22	5.60	0.00	5.60
Corollary	2.00	1.99	0.26	7.30	0.00	7.30
Medical	1.35	1.49	0.19	5.90	0.00	5.90
Maint.	0.69	1.47	0.19	8.30	0.00	8.30
Hygiene	0.40	0.25	0.03	1.10	0.00	1.10
Training	0.71	0.49	0.06	2.00	0.00	2.00
Hskg.	1.12	1.19	0.15	4.80	0.00	4.80
R and R	0.30	1.02	0.13	5.60	0.00	5.60
Student	0.17	0.39	0.05	1.80	0.00	1.80
EVA	0.68	2.32	0.30	12.00	0.00	12.00
L and R	0.28	1.53	0.20	9.10	0.00	9.10
Act/Deact.	0.51	1.90	0.25	10.00	0.00	10.00

Table 3-4

ACTIVITY STATISTICS (HOURS) — SKYLAB II SCIENCE PILOT, GARRIOTT

Activity	Mean	Std Dev	Std Err	Max	Min	Range
Sleep	7.84	1.16	0.15	9.70	0.00	9.70
Eat	4.35	1.45	0.19	8.00	1.00	7.00
ATM	3.34	2.56	0.33	9.00	0.00	9.00
EREP	0.76	0.98	0.13	3.10	0.00	3.10
Corollary	0.89	1.40	0.18	6.10	0.00	6.10
Medical	2.09	1.93	0.25	8.20	0.00	8.20
Maint.	0.18	0.53	0.07	2.00	0.00	2.00
Hygiene	0.48	0.29	0.04	1.20	0.00	1.20
Training	0.63	0.43	0.06	1.10	0.00	1.10
Hskg.	0.98	0.93	0.12	4.20	0.00	4.20
R and R	0.26	0.77	0.10	4.00	0.00	4.00
Student	0.67	1.54	0.20	10.50	0.00	10.50
EVA	0.45	1.83	0.24	11.60	0.00	11.60
L and R	0.32	1.56	0.20	9.10	0.00	9,10
Act/Deact.	0.56	2.01	0.26	10.70	0.00	10.70

operation, corollary experiment attendance, medical experiments and student experiment and television operations. Column 4 is a summary of the daily time spent by the crew on stationkeeping activities as monitored above. Table 3-8 is a statistical summary of the data contained in Table 3-7 and presents the daily time division averages alluded to at the beginning of this section.

Figure 3-4 is a plot of the frequency distribution of the total daily crew time devoted to experiment operations. This plot was computer-generated and each star (*) represents one of the 60 mission days. The average of 23.84 hours for the three crewmen represents about eight hours available from each to devote to experiment and payload activities. Figure 3-5 suggests that the distribution of Skylab experience follows a trimodal characteristic. A Poisson-like distribution characterizes eight days out of the mission where on the average only 3.12 hours were spent on experiment operating by all the

Table 3-5

ACTIVITY STATISTICS (HOURS) – SKYLAB II PILOT, LOUSMA

Activity	Mean	Std Dev	Std Err	Max	Min	Range
Sleep	7.84	1.17	0.15	9.70	0.00	9.70
Eat	4.17	1.34	0.17	7.00	1.00	6.00
ATM	2.12	2.02	0.26	7.00	0.00	7.00
EREP	1.55	1.74	0.22	6.20	0.00	6.20
Corollary	1.75	1.58	0.20	5.50	0.00	5.50
Medical	1.78	1.86	0.24	7.50	0.00	7.50
Maint.	0.30	0.62	0.08	2.00	0.00	2.00
Hygiene	0.45	0.22	0.03	0.90	0.00	0.90
Training	0.78	0.40	0.05	1.50	0.00	1.50
Hskg.	1.17	1.23	0.16	6.60	0.00	6.60
R and R	0.22	0.70	0.09	3.50	0.00	3.50
Student	0.05	0.14	0.02	0.60	0.00	0.60
EVA	0.77	2.50	0.32	12.00	0.00	12.00
L and R	0.28	1.53	0.20	9.10	0.00	9.10
Act/Deact.	0.59	2.06	0.27	10.50	0.00	10.50

crewmen. These days out of the mission would fall in the periods of activation and deactivation of the station when most of the crew time is required to verify system operation and prepare the spacecraft for routine operations to follow or secure for the unmanned periods. The second class of operations follows a typical Gaussian distribution associated with normal day-to-day routine. Here 54 percent of the Skylab II mission days were involved where on the average 27.9 hours total was available for experiment activities. A second Gaussian distribution, with a mean of 32 hours total, is observed and is characteristic of those extraordinary operations, such as EVA, where the crew devotes the maximum amount of available time to experiment operations.

Another question addressed by the study dealt with the amount of learning which can be expected in the crews on extended missions. Learning in this case refers to the degree of adaptation to the zero-g environment which can

Table 3-6

AVERAGE STATISTICS (HOURS) – THREE SKYLAB II CREWMEN

Activity	Mean	(%)	Std Dev	Std Err	Max	Min	Range
Sleep	7.92	33.0	1.15	0.15	9.70	0.00	9.70
Eat	4.32	18.0	1.34	0.17	7.00	1.00	6.00
ATM	2.50	10.4	1.52	0.20	4.80	0.00	4.80
EREP	1.25	5.0	1.40	0.18	4.70	0.00	4.70
Corollary	1.55	6.5	1.16	0.15	5.10	0.00	5.10
Medical	1.75	7.5	1.35	0.17	5.20	0.00	5.20
Maint.	0.39	1.6	0.72	0.09	3.40	0.00	3.40
Hygiene	0.44	1.8	0.21	0.03	0.90	0.00	0.90
Training	0.71	3.0	0.33	0.04	1.50	0.00	1.50
Hskg.	1.09	4.6	0.92	0.12	4.80	0.00	4.80
R and R	0.26	1.1	0.69	0.09	2.90	0.00	2.90
Student	0.30	1.3	0.54	0.07	3.50	0.00	3.50
EVA	0.63	2.6	2.10	0.27	11.80	0.00	11.80
L and R	0.29	1.2	1.54	0.20	9.10	0.00	9.10
Act/Deact.	0.55	2.4	1.97	0.25	10.40	0.00	10.40

be expected and the attendant improvement in efficiency in task performance resulting from longer periods in space. To resolve this question, data obtained during the 88-day third Skylab mission (Skylab III) was examined and analyzed within the context of Experiment M151, "Time and Motion Study," as reported on by Joseph F. Kubis, et al. [1]

Figure 3-6 presents the three selected tasks, the mean values and standard deviations of performance times for the initial, middle and final third of this mission. The Kubis data was acquired inflight during the conduct of three medical experiments: M092 Inflight Lower Body Negative Pressure, M171 Metabolic Activity, and M093 Vectorcardiagram.

[1] The Proceedings of the Skylab Life Sciences Symposium, Volumes I and II, NASA Technical Memorandum TM X-58154 (JSC-09275), dated November 1974, pp. 307-339.

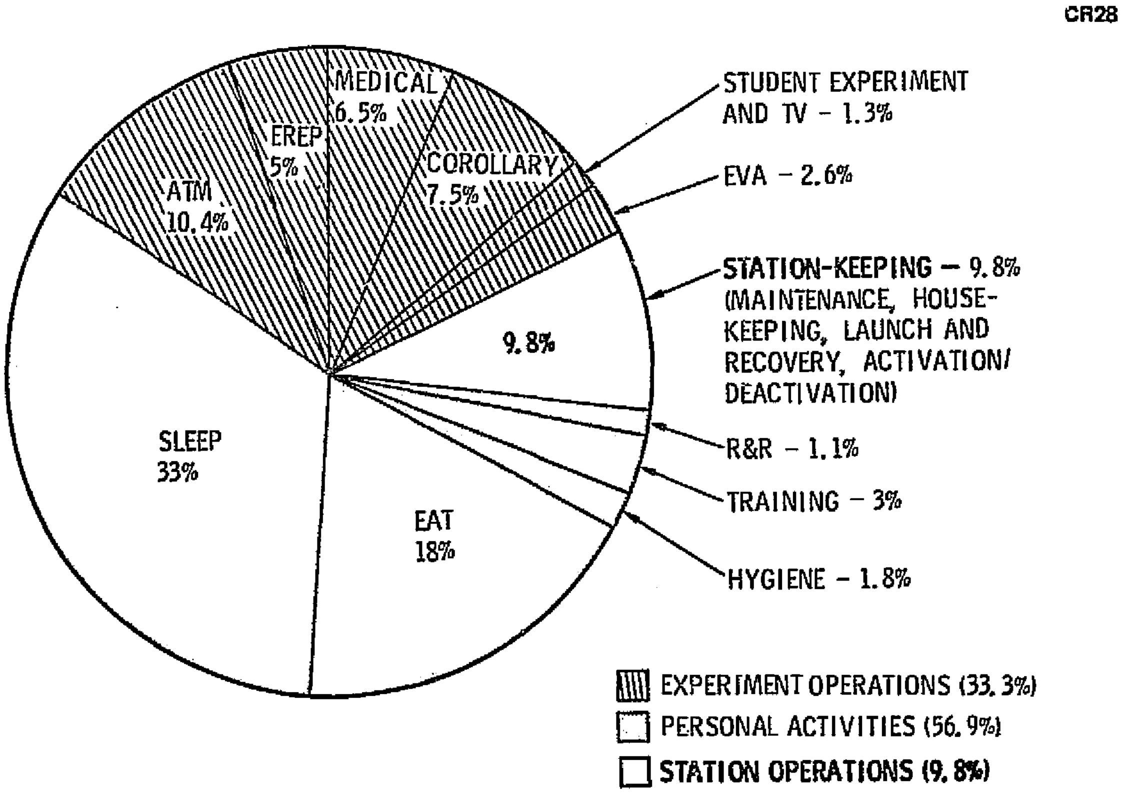

Figure 3-3. As-Flown Skylab II Flight Activities

When the data points are connected by the best fitting straight lines on log-log grid paper, an estimate of the learning (performance improvement) experienced during the mission can be made. As noted on the graph continuing performance of M092, M171 and M093 resulted in learning curve slopes of 87 percent, 72 percent, and 84 percent, respectively. In light of this experience, it is believed reasonable to utilize a learning factor of 85 percent for MOSC missions when extrapolating the manhours required for a specific set of activities.

The Skylab experience is invaluable when guidelines need to be developed for future manned space system concepts. From insights gained during the active mission periods when problems had to be solved "in real time" and adjustments

Table 3-7 (Page 1 of 2)

COMBINED GROUPED ACTIVITY TIMES FOR "AS-FLOWN" FLIGHT PLAN - SKYLAB II

Mission Day	Personal Duties (hr)	Experiment Operations (hr)	Station Keeping (hr)	Daily Total (hr)
01	32.70	.00	39.30	72.00
02	39.00	1.80	31.20	72.00
03	45.80	2.30	23.90	72.00
04	55.70	2.60	13.70	72.00
05	45.80	21.20	5.00	72.00
06	47.70	19.10	5.20	72.00
07	48.50	21.10	2.40	72.00
08	43.40	21.20	7.40	72.00
09	43.70	27.10	1.20	72.00
10	36.40	35.60	.00	72.00
11	47.90	21.40	2.70	72.00
12	46.70	21.40	3.90	72.00
13	46.30	16.70	9.00	72.00
14	48.80	9.40	13.80	72.00
15	44.90	24.20	2.90	72.00
16	41.00	29.80	1.20	72.00
17	46.70	24.00	1.30	72.00
18	47.50	22.50	2.00	72.00
19	45.10	25.00	1.90	72.00
20	42.20	27.90	1.90	72.00
21	40.40	30.70	.90	72.00
22	50.00	15.40	6.60	72.00
23	41.60	26.30	4.10	72.00
24	38.50	22.10	11.40	72.00
25	41.30	29.60	1.10	72.00
26	39.10	28.10	4.80	72.00
27	39.50	25.00	7.50	72.00
28	34.60	36.00	1.40	72.00
29	42.10	24.10	5.80	72.00
30	45.80	17.50	8.70	72.00
31	36.90	32.10	3.00	72.00
32	39.10	30.90	2.00	72.00
33	37.70	32.40	1.90	72.00
34	39.30	29.40	3.30	72.00
35	37.60	30.00	4.40	72.00
36	36.30	31.50	4.20	72.00
37	41.90	25.10	5.00	72.00
38	39.60	30.20	2.20	72.00
39	37.50	32.50	2.00	72.00
40	40.00	26.70	5.30	72.00
41	42.30	26.90	2.80	72.00
42	42.90	23.20	5.90	72.00

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Table 3-7 (Page 2 of 2)

COMBINED GROUPED ACTIVITY TIMES FOR "AS-FLOWN" FLIGHT PLAN - SKYLAB II

Mission Day	Personal Duties (hr)	Experiment Operations (hr)	Station Keeping (hr)	Daily Total (hr)
43	38.20	30.30	3.50	72.00
44	42.70	24.30	5.00	72.00
45	38.80	31.30	1.90	72.00
46	36.40	30.00	5.60	72.00
47	35.20	31.90	4.90	72.00
48	38.10	32.30	1.60	72.00
49	38.70	29.40	3.90	72.00
50	37.40	30.10	4.50	72.00
51	47.20	24.40	.40	72.00
52	34.40	34.50	3.10	72.00
53	36.20	32.40	3.40	72.00
54	38.40	27.80	5.80	72.00
55	39.40	23.00	9.60	72.00
56	36.20	32.80	3.00	72.00
57	40.50	27.00	4.50	72.00
58	38.10	8.90	25.00	72.00
59	37.40	.00	34.60	72.00
60	3.00	.00	34.90	37.90

Table 3-8

AS-FLOWN GROUPED STATISTICS (HOURS)

Activity	Mean	Std Dev	Std Err	Max	Min	Range
Personal	13.63	2.25	0.29	18.60	1.00	17.60
Experiment	8.02	3.16	0.41	12.10	0.00	12.10
Station Keeping	2.35	2.97	0.38	13.10	0.00	13.10

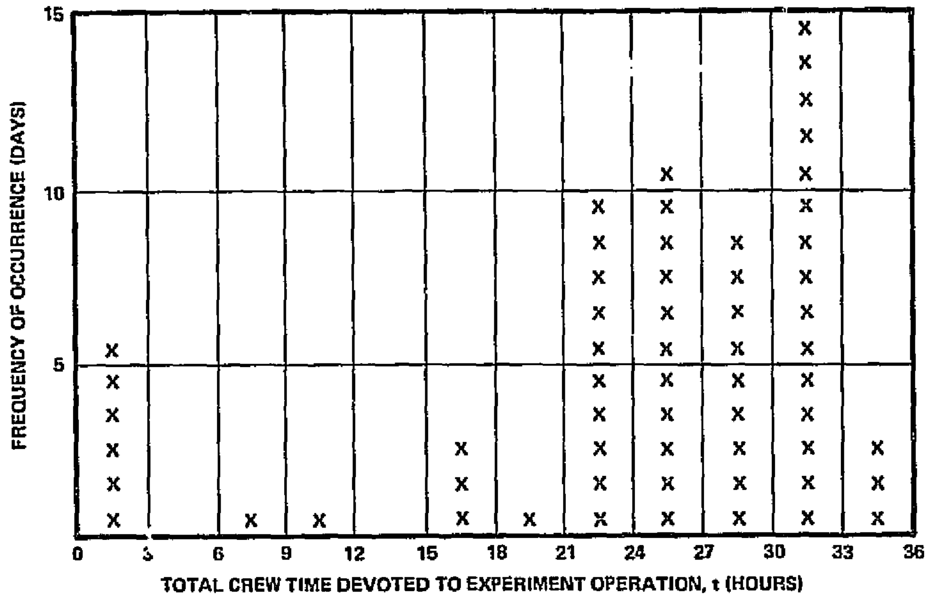

Figure 3-4. Histogram — Total Daily Experiment Activities — Skylab II

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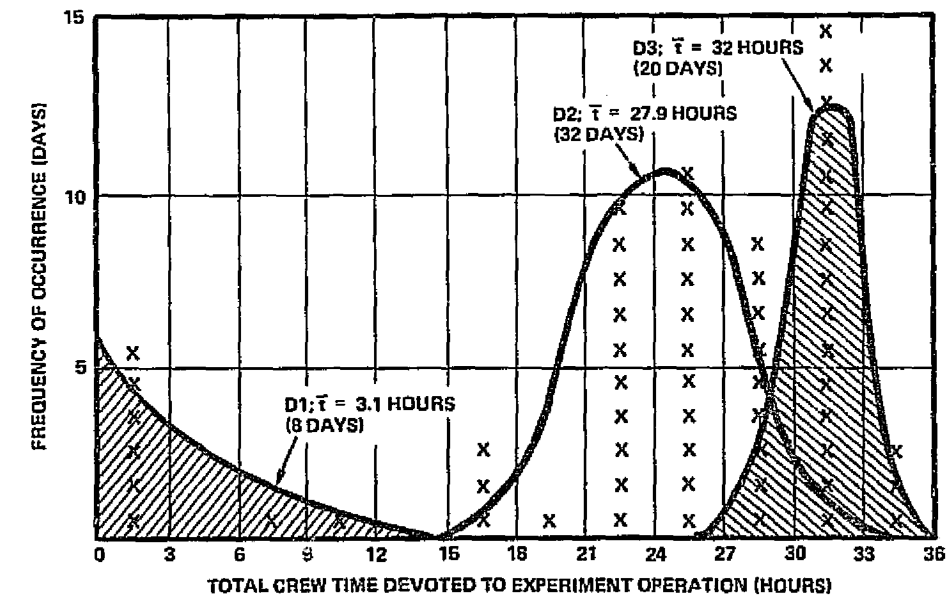

Figure 3-5. Trimodal Distribution of Experiment Operations

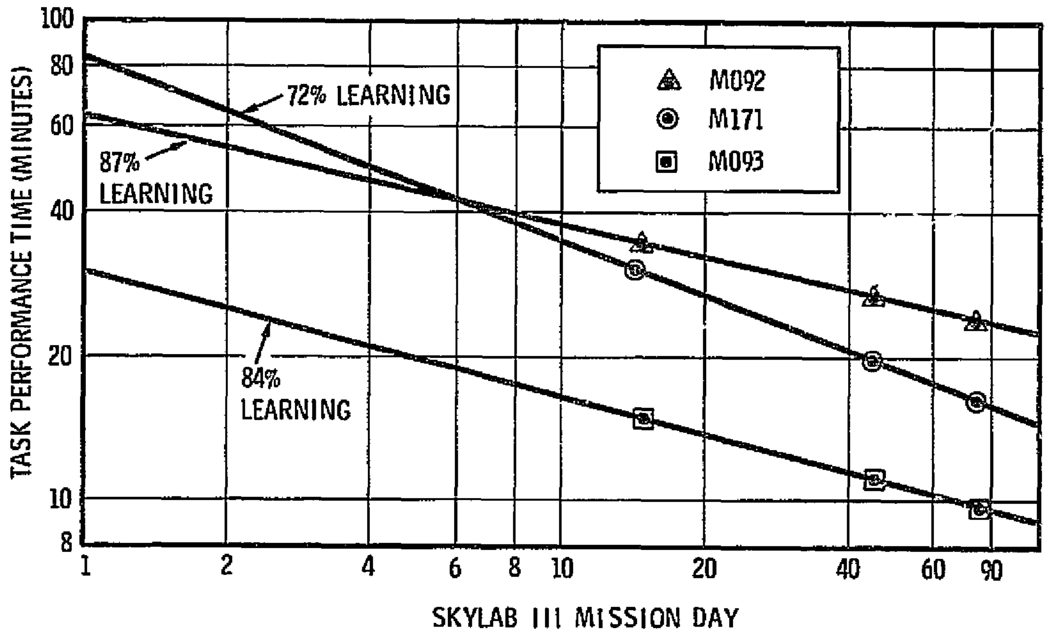

Figure 3-6. Estimate of Crew Performance Efficiency

had to be made to the flight plan on a dynamic basis, the following observations and guidelines are presented:

1. Concurrent sleeping periods for all crewmen should be considered the normal mode of MOSC operations. Flight experience has shown that alternate sleeping periods in space is not desirable. Because of the disturbances created by the non-sleeping crew members, sleeping in shifts appears only feasible for the very largest of space stations. Approximately 7 manhours of crewtime per day will be required to support station activities such as housekeeping, maintenance and planning the activities of the flight. A portion of the 7 manhours should be considered reserved for contingencies which cannot be planned or timelined in the flight.
2. The crewman would be expected to perform actual experiment operations for 8 hours of each nominal working day in orbit.

On missions in excess of 7 days, every seventh day should be an unscheduled day for "catch-up activities" or a day of nominal rest. It can be expected, however, that those tasks requiring daily performance would be continued on the seventh day although the nonessential activities would be relaxed.

3. The nominal operational day should be scheduled to provide between 10 and 12 hours of continuous experiment operations for the entire crew. This may be extended to a limit of 16 hours as particular experiment conditions warrant. Under special specific conditions it would be possible but highly undesirable to have the crew duty cycles realigned to perform round-the-clock manning, but this can be resorted to for short periods of time (approximately two days) under unusual circumstances. This is not to preclude equipment being remotely operated from the ground while the crew is sleeping and any experiments requiring 24-hour-a-day functioning should be designed to operate in this manner.

4. In some cases it can be anticipated that the crewman will be involved directly in the research activities as either the subject or the experimenter and as such will have the sole responsibility for the conduct and evaluation of the orbital research program. In other cases, the crewman will share with or yield to the operational control of counterparts on the ground. In these latter experiments (typically in the areas of astronomy, high energy physics, Earth observations and Earth and ocean studies) the ground-based personnel actually can be considered as extending the capability of the orbital facility by operating the equipment when the crew members are either not available by virtue of sleeping or are performing other experiments. Providing more experiment control to the principal investigator on the ground suggests that the on-orbit crew skills will tend to fall into two classes, i.e., those of a laboratory support technician in some areas, and those of a principal investigator in others. For 46 candidate experiments examined, only 5 identified the need for the physical presence of the principal investigator.

Using the Skylab results as the initialization point, Table 3-9 and Figures 3-7 and 3-8 relate experiment manhours to various mission durations for several crew sizes. Table 3-9, Manpower Available During Flight, shows the manhours available for a two-man crew for 7-, 30-, 60-, and 90-day flights. Figure 3-7 shows the summation of manhours available for crew sizes of two, four and six. Figure 3-8 plots various crew sizes and mission durations for the required experiment manhours versus the number of flights required.

Table 3-9

CALCULATION OF MANPOWER AVAILABLE DURING FLIGHT

Flight Duration	Net Work Days	MH/ Day	Days Off	Crew Size: Two Men	Four Men	Six Men
7 days:	(7-2)	X8	X1	80	160	240
30 days:	(30-2)	X8	X6/7	384	768	1152
60 days:	(60-2)	X8	X6/7	795	1590	2385
90 days:	(90-2)	X8	X6/7	1207	2414	3621

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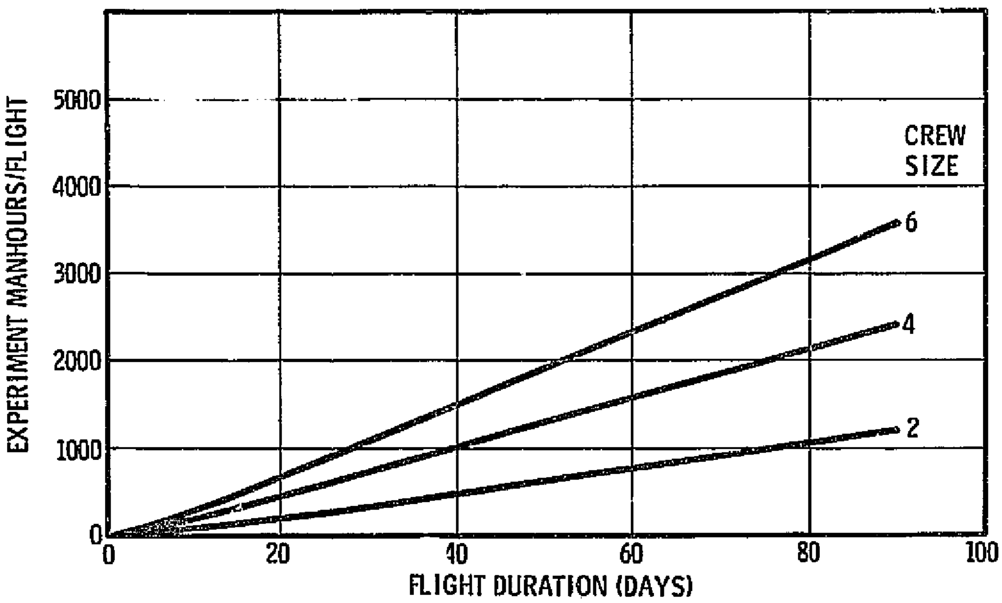

Figure 3-7. Available Manhours

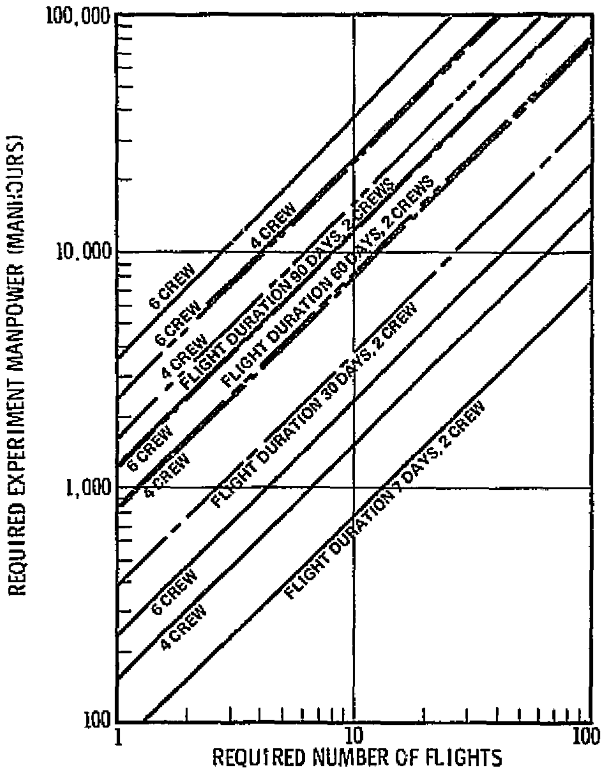

Figure 3-8. Flight Scheduling Requirements

3.4 OTHER FACTORS TO BE CONSIDERED

In some cases during relatively short flights, continuous around-the-clock operations need to be scheduled in order to perform the prescribed observations within the available time. These classes of requirements could demand larger crews necessitated by multiple shift operations. If longer flight times were available, then the observations could be made by single shift operations to accomplish the same job. Normal crew motion may involve low levels of mechanical disturbances and forces and payloads which are sensitive to these disturbances should be identified so that protective and/or preventative measures can be provided. These measures can be scheduled and include restricted crew activities and location of the crew near the center of gravity of the station during critical periods of the flight.

3.5 REFERENCES AND OTHER SOURCE MATERIAL

The sources of information that were examined and used during the study included documented results of the experience gained during the Skylab Program. For example, the 13 Skylab Experience Bulletins provided useful

commentary on such subjects as translation modes, airlock requirements, sleeping quarters, sleep restraints, inflight maintenance, space garments, personnel restraints, cleansing provisions, tools and test equipment, and supplies required for inflight support operations. Additional insight was provided by the lessons learned from the Skylab Program reports.

Section 4
REQUIREMENTS FOR EXTENDED CAPABILITY

The advantages to be gained by extended-capability missions for each of the 46 payloads (Table 2-2) were assessed. It was noted that in no case were there payloads that would be adversely affected by longer than 7- to 30-day durations. In the life science and space processing areas there were new fields of research which could be addressed by longer missions.

In examining the impact of the research requirements and/or advantages of extended capabilities, the following five major capability extension areas were considered for each payload:

1. Flight Duration — Exposure time, observation opportunities
2. Weightlessness — G-levels, gravity-induced disturbances
3. Contamination — Physical, chemical, thermal, electromagnetic
4. Resources — Weight, volume, power, energy
5. Schedule — Number of flight, equipment items, economies, practicalities.

The capability areas generally found to be important in each payload discipline are summarized by discipline in Table 4-1. In assessing the requirements for extended capability, discussions were held with NASA personnel involved with payload studies and payload planning activities in each of the discipline areas. Additionally, other scientists were contacted for their views of the valve and requirements for extended capability. In summary the results of these discussions are as follows. For the astronomical payloads, driving requirements are a contamination-free environment and an opportunity to make observations undisturbed by the other operations of the facility. In high-energy astrophysics the primary concern is the deployment of the massive detector elements in space for a sufficient period to record a statistically significant number of cosmic ray events. In the case of solar physics, the ability to observe at

Table 4-1

PAYLOAD REQUIREMENTS FOR EXTENDED CAPABILITIES

	Capability Extension Areas				
Payload Disciplines	Flight Duration	Weight-lessness	Contamina-tion	Resources	Schedule
Astronomy	X	X	X		X
H. E. Astrophysics	X			X	
Solar Physics	X				
AMPS	X		X		
Earth Observations	X				X
E and O Physics	X				X
Life Science	X	X			X
Space Processing	X	X	X	X	X
Space Technology	X	X	X		
Comm/Nav	X				X

least one solar rotation cycle (approximately 28 days) was important and flight durations of 60 days would be desirable in order to capture two solar rotations. Extended flight durations are also highly desirable in Earth observation and Earth and ocean physics where clear weather coverage and multiple passes over a given geographical location are important to the researchers. In life science, long-duration flight experience is mandatory to study the role of gravity in life processes. The AMPS and comm/nav investigations are to a lesser degree dependent upon extended flight duration. The space processing and space technology disciplines are most concerned with maintaining a microgravity-disturbance-free environment for conduct of the experiments. The discussions which follow probe in greater detail the advantages to be gained by mission extension for each of the ten discipline areas.

4.1 ASTRONOMY

Space-based astronomy takes advantage of the orbital vantage point to make observations in those regions of the spectrum not available from ground observatories and to reduce the obfuscations resultant from atmospheric

effects such as sky light, twinkle and flint which limit resolution and recording time. Specifically, the regions of the spectrum in the IR from 10 to 1 micron and the UV from 2,000 to 50 angstroms, not available on Earth, can be observed from space. In addition the high regions of the spectrum extended to gamma ray frequencies, which are absorbed by the atmosphere, become accessible from space.

It is a well-known fact that Earth-bound astronomical instruments of large aperture (>3 meters) experience atmospheric degradation before theoretical resolution limits are encountered. In theory, space-based instruments of these larger apertures will not experience degradation and therefore could be expected to perform to their theoretical diffraction limits if so constructed. However, the larger aperture, finely figured optics, space telescopes can be adversely affected by local conditions experienced in the space vehicle environment. The reflective characteristics of the instrument optics are particularly sensitive to contaminants such as non-volatile hydrocarbon (strong absorbers in the UV) which can deposit on the optical surfaces. Therefore, one of the most desirous improvements in capability would be a well-controlled low level of contaminants.

Another important consideration is a vibration-free, precision pointing, all attitude stable mount. The larger instruments (apertures >1 meter) when performing to diffraction limited capabilities can resolve sources with angular separations of about 0.1 second (at 4000 angstrom) and below). This level of performance requires an equally precise stable mount to isolate the instruments from mechanical disturbances and perturbations introduced by other space system elements. When operating attached to the Spacelab and/or Orbiter sources of disturbances which are difficult to isolate against include periodic thrustor firings, vibration from rotating machinery, crew motion and thermal creep. The attached mode of operation is also subject to sources of particulate and chemical contamination resulting from outgassing, venting and engine firings. The extended capability offered by a free-flying platform could serve to alleviate both the stabilization and disturbance problems and the contamination situation encountered in an attached-to-the-Shuttle mode of operation.

Flights of longer duration (>30 days) also offer desirable advantages to space astronomy. While individual observations do not require excessive periods of time, series of observations as encountered in sky surveys and star field mapping do require extended periods (>30 days) for completion. When these classes of astronomical activities are structured within 7-day flight mission segments, then either multiple instrument sets are required to accomplish the work within a fixed number of flights or many flights are required to satisfy the requirements of the observation program. It is far more desirable from the scientific point of view to perform the measurements with a single instrument of known and well-established performance characteristics than to use several similar instruments. No two astronomical instruments perform exactly alike. Individual idiosyncrasies that are observed from instrument to instrument include such differences as exact focal length, resolving power, spectral characteristics, magnification, field linearity, pointing accuracy (exact hour and declination angles) and so forth. Using a single instrument to perform an all-sky survey would ensure that all frames of the total set would exhibit the same scale and resolution. Also, instruments used for astronomical observation experience changes in certain characteristics with passing time. These changes occur as components creep or drift and as wear sets in. The most desirable operation would be to start and finish one particular survey in a single continuous mission where the instrument would be subjected to the minimum amount of disturbances during the course of the observations. Little is known of the effects on instrument performance by having to transport it several times by means of the Shuttle transportation system, by numerous startup and shutdown cycles, by experiencing different operators and crew members from flight to flight, and so forth. Calibrations would have to be repeated often and the data adjusted for each flight on an individual basis to match all the data for correlative purposes. In short, longer-duration flights would greatly simplify and remove uncertainties from those to be expected with shorter orbital stay times.

4.2 HIGH-ENERGY ASTROPHYSICS

The study of cosmic rays is concerned with the scientific issue of the origin and composition of the universe, a most profound subject indeed. Information is sought concerning the spectra, energy and flux of particles and

electromagnetic radiation which cannot be detected on the ground due to interactions of the cosmic rays with the constituents of the atmosphere. The study of isotopic abundancies for the heavier transition elements reveals clues of the individual age or life cycle of a particle encountered. The problems facing the scientists in this area of research center around the extremely low level of flux (incidence of cosmic ray events) and the extreme energy levels of the cosmic rays to be measured.

There are two presently used experimental methods in high energy astrophysics investigation, both of which center around the cosmic ray detection mechanism. The first attempts to measure the rays directly by their interaction with an active detector where controlled electrical and magnetic forces are indicative of the phenomena observed. Because of the energetic properties of these rays very high electrical and magnetic fields are required necessitating the employment of such advance techniques as superconducting magnetic devices which present state-of-the-art calls for cryogenic cooling to near the absolute zero point. The magnet is used to cause the charged particles to bend to be able to separate the species and thereby obtain the identity of the chemical composition and isotopic abundances of the cosmic ray. In order to measure the energy of the rays ordinarily a total absorption detector is employed. This device is needed to stop the cosmic rays so that their energy can be measured. One of the most important characteristics of the detector is its geometric factor. That is, a certain sized detector can stop particles of certain energy levels: the larger the factor, the higher the energy levels measurable. Along with the geometric factor is a time factor. That is, with a low flux rate of cosmic rays to be observed, then one must expect that a longer period would be required to experience an encounter. The geometric factor and the time factor form a product which should be as large as possible. When the detector size is limited by practical constraints, then the flight duration becomes the pacing requirement.

The other approach to measuring cosmic rays consists of an array of emulsions which are essentially passive elements (they do not require power or cooling provisions). The emulsions can be either silver halide photographic detectors or other substances such as plastic sheets wherein the cosmic ray encounter histories are recorded in the emulsions. Upon development of the

emulsions the histories of the particle interactions with the emulsions are indicative of the properties of the rays. These schemes differ from the active approach in that there is no real time readout possible. However, they possess the same geometric time factor product criteria as before.

Professor P. Buford Price, Department of Physics, University of California Berkeley is one of the Skylab principal investigators interested in cosmic ray research from space. Contact through his research assistant, E. K. Shirk, provided most valuable insights into the importance of extended capability to their research interests. Professor Price's experiment, Trans-Uranic Cosmic Rays (S228), provided the recording of 130 cosmic ray events of interest during the 253 days of Skylab space exposure. In this experiment it was the numerical product of detector volume and exposure time, as mentioned above, that is the pacing parameter. In future space experiments these scientists state that it would be desirable to increase the time-volume product by 50-100 and increase the detector density by a factor of three. For MOSC era missions a natural tendency would be to increase the mission duration thereby reducing the amount of detector volume with payoff of decreased payload delivery and return weight. Experimental interest, circa 1984, might well be directed toward the investigation of isotopic abundances in rare heavy elements in cosmic rays. These investigations require larger volume-time products in order to gather a statistically sufficient number of events to provide the identification of the isotopes detected. This interest would necessitate longer duration missions involving relatively massive payloads.

4.3 PHYSICS

4.3.1 Solar Physics

Raw numbers of available and planned observing hours can be misleading in assessing the true objective temporal requirements of a solar observation program. Figure 4-1 portrays the time and space scale of certain typical solar phenomena. The abscissa of the chart depicts on a logarithmic scale the periodicity and lifetime of certain solar events. These cyclic phenomena range from subsecond events at the lower end of the scale to those extending beyond the 22-year observed solar activity period. A program of at least 3800 hours of discretely spaced observations extended across one or more 22-year cycles would be adequate to fully cover the solar activity changes.

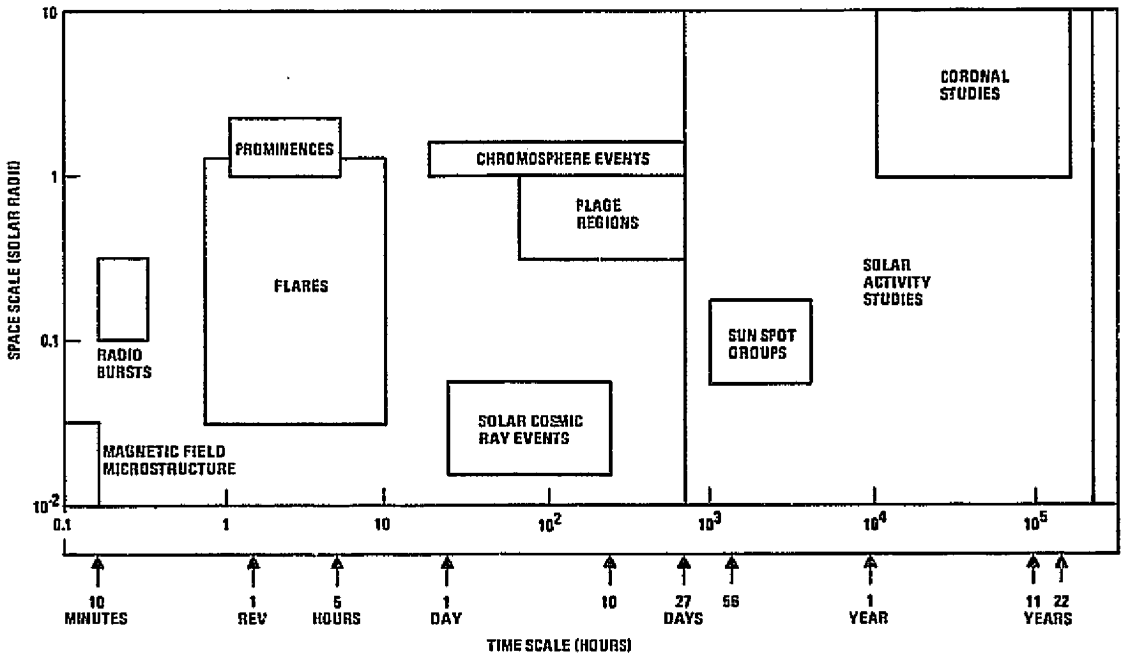

Figure 4-1. Solar Phenomena Range and Extent in Time and Space

The data returned by the Skylab Apollo telescope mount experiments proved to be both event-oriented and statistical in nature. Events such as bursts, fluxes and solar cosmic ray events were observed where the onset of the phenomena was of utmost concern and interest. Needs remain for both high rate observation of transients and long term coverage of the basic solar activity cycles. Both requirements drive toward longer periods to make observations and toward periods when continuous or near continuous observations are desirable.

Figure 4-2 shows application areas that could be expected to benefit from the indicated study of solar phenomena. For example, improved and more accurate long range weather forecasts will undoubtedly result from new insights and fuller scientific understanding of solar activity cycles. Long term observations of the sun will lead to improved analytic and descriptive models of the sun and its interaction with the Earth's atmosphere. Another instance of terrestrial application of solar studies is in the area of coronal studies. Observation and analysis of the mechanisms and sources of coronal heating which is currently only partly understood can bring additional insight

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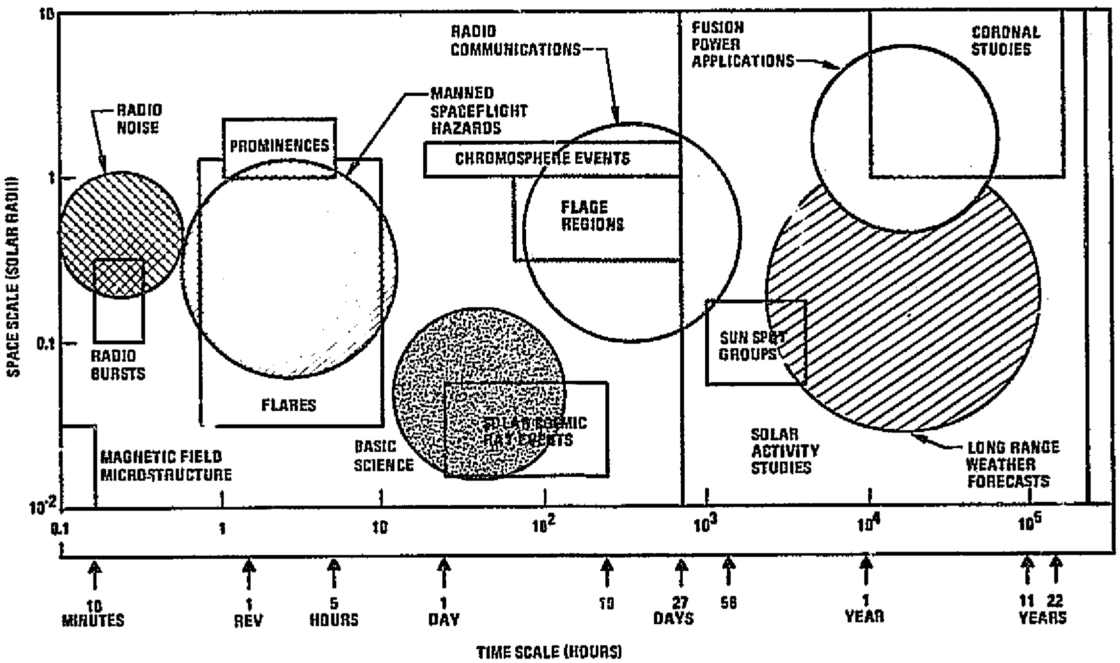

Figure 4-2. Solar Phenomena Research Implications

and understanding of magnetohydrodynamic processes with future power source implications.

Observations of the sun are bound to remain a very important area of scientific interest. Extended capabilities in space will enable the solar physicist to pursue new areas of research with potentially important implications to mankind.

4.3.2 Atmospheric, Magnetospheric, and Plasma Physics in Space (AMPS)

The AMPS investigations involve measurements of the characteristics of near-Earth space. For the most part observations of atmospheric and magnetospheric phenomena, as opposed to the plasma and plasma sheath experiments, will benefit from longer exposure periods to permit the acquisition of data by means of a continuous set of measurements using the same calibrated instruments. Here the remote sensing missions would benefit from long durations to observe atmospheric changes occurring on a seasonal basis and as influenced by variations in the energy and spectra of the solar input during solar activity cycles. Flight durations of 60 days and longer are desirable.

In the plasma physics area certain of the investigations require the release of vaporized chemicals. Upon release these chemicals become partially ionized and, because they dissipate fairly quickly (one to two hours), extended duration flights provide the opportunity to make numerous releases at different places in the orbit thereby covering much more area than possible with single releases. This added flexibility is most desirable in the planning and conduct of the perturbation experiments.

4.3.3 Earth Observations and Earth and Ocean Physics

The SSPDA payloads associated with these two application categories largely contemplate flights where the major purpose of the mission is to qualify the basic instruments and sensors for operational use. As such these applications do not demand extended capability or longer duration missions. It can also be expected that the shorter sortie class missions will allow for only limited coverage of the entire globe for all of the various conditions that could be encountered. Many of these limitations can be avoided by longer flight periods which would permit repeated observations over the same site and would make available coverage of an area by a subsequent orbital pass when the first planned pass encountered cloud cover or some other local conditions which could negate the observational opportunity.

Another aspect of longer duration flights is that it would be possible to plan a series of investigations perhaps of international scope and participation. As was experienced by the International Geophysics Year 1957-1958 (IGY) a worldwide program of Earth-oriented research could be conducted with the cooperation of many nations and thousands of individual scientists. The IGY approach can be directed toward a systematic study of the Earth and its environment and a semi-permanent orbiting laboratory could serve as the observation focal point of the program.

4.4 LIFE SCIENCES

With flight durations limited to 7 to 50 days' duration the extent of the life science research program would of necessity be limited. For example, the following list summarizes some of the important areas of investigation requiring more than 30 days in orbit:

1. Two generations of man surrogates (small animals)

2. Calcium and collagen bone development and/or repair (mineral metabolism)
3. Vision
4. Electrolytes
5. Exercise (amount and types)
6. Cardiovascular dynamics
7. Hematology
8. Dose response g capability
9. Psychomotor adaptation to zero-g
10. Habitability (living and working architecture)
11. Work/rest schedules
12. Small group dynamics
13. Plants (seed-to-seed generation)
14. Countermeasures
15. Life support system components (for long-duration manned missions, i.e., Mars)

The life science discipline, perhaps uniquely over all the other disciplines, requires longer-duration flights and missions. While shorter periods (seven to 30 days) can be useful to investigate responses to the change in gravity stimuli in space, these periods are not sufficiently long to study the adaptation of life forms to weightlessness. It is in the adaptation phenomena that answers to questions are sought as to the role of gravity in biological processes and mechanisms. In this area of research durations extending to two years are needed to meet the scientific objectives.

4.5 SPACE PROCESSING

In attempting to establish objectives and characteristics of materials processing research in space and to supplement the data derived from the source documents, Skylab experiment principal investigators were contacted during the course of the study. Informal discussions were concerned with the scientific benefits and research advantages of longer than seven to 30-day duration mission periods insofar as their individual fields of interest and experimentation were affected. The scientists expressed keen interest in extended flight periods for their experiments.

One of these was Professor William R. Wilcox of the College of Engineering, University of Southern California. Professor Wilcox's work is concerned with the material sciences and space processing. His Skylab experiment, Mixed III-V Crystal Growth (M563), was aimed at determining how weightlessness affects directional solidification of binary semiconductor alloys. These types of studies requiring longer periods in space can be contrasted to those experiments such as crystallization from a melt (e.g., the Czochralsky method of crystal growth) and zone refining which can be accomplished in a relatively shorter period of time. One example requiring longer periods in space cited by Dr. Wilcox and which could have high economic interest, was growing synthetic calcite crystals where the natural supply of calcite is being rapidly depleted on Earth. The growth of commercially useful crystals of this sort would require periods of several weeks duration.

The work of Professor Wilcox is representative of the class of research in the materials science area directed toward producing substances with unique electrical or mechanical properties. The thrust of this research area is highly applications oriented; that is, the development of production techniques for materials which have immediate use in industry as base material for solid state devices and as elements for super efficient structural configurations.

In the opinion of Professor Wilcox, every Skylab materials science experiment produced some valuable and unexpected results. At the beginning of his involvement in the Skylab experiment program Professor Wilcox was skeptical. However, now that the mission results are in he is a strong advocate of further materials science missions in space. He is particularly interested in the capabilities that MOSC can offer. Professor Wilcox's experience is typical of the other Skylab principal investigators who were concerned with materials science and manufacturing in space. For example, Dr. Harry Wiedemeir of Rensselaer Polytechnic Institute revealed great promise for space processing in his Skylab experiment Vapor Growth of II-VI Compounds (M556). As a group these scientists provide invaluable insights as to the directions that further space processing efforts should take.

One of the most severe problems encountered in terrestrial materials science

experiment and production activities involves the crucible. These problems involve contamination of the melt by the walls of the crucible. Various levitation schemes have sought to eliminate this source of trouble with varying degrees of success. Containerless melting and processing are possible attractive methods to be employed in space especially on extended durations.

Electron beam heating, as opposed to induction heating, is considered the most efficient method of applying heat to the process. The power requirements of a silicon crystal production machine utilizing a floating zone method to produce a 3- to 4-inch diameter specimen are estimated at 20 kW as an upper limit. This amount of power required could be reduced by employing the proper insulation techniques. One technique suggested by Professor Wilcox's work involves a glass cylindrical shroud with a thin gold film deposited on the inner surface of the glass. The gold film acts as a very efficient reflector of the infrared radiation but still permits the visible portion of the spectrum to pass, thereby facilitating visual observations and photographic recording of the process. With this insulation approach, the power requirement could conceivably be reduced tenfold.

The production of semiconductor quality silicon has large economic interest especially in the manufacture of large scale solar cells for the direct conversion and production of electrical energy from sunlight. In space silicon crystals can be produced at the rate of a few inches per hour so that a flight duration of a few days would be adequate to produce a single specimen. Extended periods would provide the opportunity to continue the production process and produce many crystals from the same setup.

Another space processing technique involves the production of eutectic materials. Potentially valuable commercial eutectics include certain binary mixtures. When these mixtures solidify, one of the two phases can form fibers, filaments, or platelets in a matrix of the second phase. These matrix form eutectics produced on Earth are limited in perfection by the presence of discontinuities, faults and surface irregularities caused by mechanical vibrations and thermal convection in the melt during solidification. In most cases, these defects render the Earth-produced materials ineffective or useless for solid-state devices. If the solidification process is performed

in a space environment, where convection is reduced to near zero by the null-gravity and where vibration and mechanical disturbances are minimized in free flight, one can expect to produce continuous fiberlike eutectics with special electrical, thermomagnetic, optical and superconducting properties with immediate commercial value. The Skylab experiment M564, Metal and Halide Eutectics, provided investigators Yue and Yu[2] with sufficient evidence to indicate that space-produced matrix materials display certain superior properties compared to Earth-produced control ingots. Eutectic work requires flights of at least seven days and it is desirable to have longer duration exposures of 30 days or more.

Another space processing technique involves the growing of crystals from a liquid or vapor phase. These processes are characterized by a relatively slow growth rate on Earth to produce perfect crystals free from dislocations and surface defects. Since it requires weeks to produce specimens of industrial value, liquid and/or vapor grown crystal production are candidates for the longer duration space manufacturing missions. Professor H. Wiedemeier and associates on Skylab experiment M556, Vapor Growth of II-VI Compounds, demonstrated the positive effects of null-gravity on crystal growth.[3] Considerable improvement was observed in the space crystals over the ground-grown controls in terms of surface perfection, crystalline homogeneity and defect density. These features are mandatory if the produced materials are to be of economic value. Further it was observed that greater mass transport rates were produced than were expected in null-gravity. This evidence is of basic scientific and technological significance and is indicative of the improved efficiencies experienced in the space environment. The conclusions drawn from Professor Wiedemeier's investigations are readily adaptable to the growth of commercially important electronic materials. This process requires extended flight durations up to 60 days.

Another important possibility for space processing is in the area of the health

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[2] Halide Eutectic Growth, A. S. Yue and J. G. Yu, UCLA, pp. 469-489, Proceedings Third Space Processing Symposium, Vol. 1, MSFC Report M-74-5, June 1974.

[3] Vapor Growth of GeSe and GeTe Single Crystals in Microgravity, H. Wiedemeier, F. C. Klaessig, S. J. Wey, and E. A. Irene, Rensselaer Polytechnic Institute, pp. 235-256, ibid.

sciences. Medical interest is centered around processes to separate living cells which are difficult to accomplishment by ordinary physical or chemical means. One such technique, termed electrophoresis, offers promise to separate cells by taking advantage of their electric surface charge and potential differences. On Earth the size and dimensions of the electrophoresis tube are limited because of buoyancy; that is, larger size tubes are affected more quickly by convection, settling, sedimentation and other gravity related effects. By reducing the size of the tube to permit sufficient time for the electrophoresis separation to take place, only small setups and yields are possible. Other schemes to negate the gravity effects have been employed by Van Oss and Associates[4] to a limited degree. These include vertical liquid columns containing variable density mediums for electrophoretic transport of the lymphocytes. Normally, however, cells fall to the bottom of the tube in the time required for electrophoretic separation. Increasing the density of the solution creates osmotic and other problems. Thus the ideal condition for the electrophoretic separation of cells must be sought in space. This example is typical of the in vitro research, development and production in space of substances finding use in the treatment of a variety of immunological diseases, various malignancies and other types of cancer and chronic infections.

Review of concurrent study efforts at MSFC pertinent to the space processing payloads provided the study team with valuable insights regarding future mission requirements for potential MOSC applications. An appraisal of the outlook and expected development of space processing activities described space activities as evolving in three phases: (1) an early research period where the Spacelab/Shuttle capabilities appear adequate to support the basic investigations and studies of materials behavior in the microgravity environment, (2) a process development phase where individual and prototype production approaches will be evaluated in the sense of pilot-plant operations and (3) a subsequent routine industrial utilization period characterized by commercial production and manufacturing operations in space. The latter two phases of space processing will produce the driving requirements insofar as potential MOSC configurations are concerned. The system drivers are expected to be high power requirements and logistics support.

[4] Preparation Electrophoresis of Living Lymphocytes, C. J. Van Oss, P. E. Bigazzi, C. F. Gillman, School of Medicine, State University of New York and R. F. Allen, MSFC, pp. 755-762, ibid.

Four concepts are being evaluated as typical beneficial users of space during the process development and routine industrial periods. These include (1) production of surface acoustic wave components, (2) production of high-ductility tungsten, (3) separation of iso-enzymes and (4) production of semi-conductor grade silicon in a continuous ribbon form. They are discussed in the following paragraphs.

1. Surface acoustic wave (SAW) components are used in electronic circuits as frequency-sensitive elements and delay lines (filters for radar frequencies, etc.). A typical component is about 2 millimeters long and has blazed on its active surface circuits variably spaced at from 1/4 to 1/2 wavelengths. For higher frequencies these spacings approach 100 angstroms. The present Earth-bound technique to manufacture SAW components involves photographic procedures to make a mask to etch the circuits on the substrate. Vibrations and mechanical disturbances from both man-made and seismic sources limit the spacing that can be achieved to an equivalent 4 gHz upper frequency while the requirement is present to raise the limit to about 30 gHz. In the vibration and seismic disturbance free environment of space, it is forecast that circuits produced by electron beam etching techniques could satisfy an annual market of 800,000 units. It is estimated that these circuits could be produced in space during a 70-day flight which would be equivalent to ten 7-day Spacelab flights. In addition to the reduction in the number of flights required to accomplish the annual production requirement (in this case one flight versus ten for the Spacelab), a time advantage in continuous operations both for improved efficiency associated with learning experience and for elimination of startup/shutdown operations associated with each flight. The machine required to produce the circuits would weigh about 925 pounds.
2. Tungsten is used in manufacture of x-ray tube targets. The effective life of a typical x-ray tube is limited by the embrittlement of the tungsten. Highly ductile tungsten can be produced by melting and solidification under controlled conditions. On the ground the crucible and furnace are major sources of chemical contamination. In space, by using containerless melting techniques such as levitation, it is speculated that high ductility tungsten targets can be produced. The

market for these targets is about 14,300 per annum, and they could be produced during a single flight of about 56 days instead of eight 7-day Spacelab flights. As with Concept 1, similar time advantages can be experienced in learning and repeated startup/shutdown cycles. The estimated weight of the furnace is 880 pounds.

3. The separation of biological materials has tremendous significance in the health sciences field. Isolation of specific enzymes from others of similar structure by virtue of the distinctive electrical surface properties can be achieved by electrophoresis. Large-scale production of iso-enzymes, as they are called, by electrophoresis on the ground is hampered by gravity induced sedimentation. The same process in microgravity is expected to provide substantial increases in yields and purity. One postulated iso-enzyme has a market of about 1,200,000 units or kits annually, which could be produced during a single 70-day flight.
4. The production of semiconductor-grade silicon in ribbon form offers substantial savings in the manufacturing of microcircuits. By reducing the waste caused by slicing and cutting operations when using conventional silicon crystals, considerable increases in product yield can be expected. A preliminary estimate of the increase in yield at the silicon level approaches 500 percent if the material were available in the appropriate ribbon form.
5. Each of the four concepts highlighted here can be expected to share benefits of single setups for annual production runs and the advantages of leaving the heavy process and production machinery (25 to 100 times the total weight of the product produced) in space. In this extended-capability mode of operation only the raw materials would be delivered to orbit and only the finish product returned to Earth.

4.6 SPACE TECHNOLOGY

In this category of space activity a multidiscipline approach to advancing research and applications technologies is evidenced. The payloads included in this area involve specific disciplines and investigations such as chemistry and physics in microgravity, materials behavior, crystal growth, spacecraft contamination, laser communications and data transmission, entry vehicle

thermal protection, high vacuum environments (wave shield technology), sensor technology, and Earth observations. Therefore, a similar rationale for extended capability can be put forth for this discipline as has been cited for the individual disciplines that are involved in the applications areas.

4.7 COMMUNICATIONS/NAVIGATION

The issues of extended capability pertinent to this category of applications have been studied[5]. It was concluded that the total program objectives in this area might well be served by time-phasing the future options (See Figure 4-3). In this plan an early laboratory, suitable for 1-week Spacelab flights would be followed by a growth version laboratory for 1-month to 1-year flight durations and eventually a total laboratory in a station-attached configuration with orbital periods up to 10 years. In this context the growth versions of the communications/navigation applications are prime candidates for free-flying MOSC missions.

4.8 DESIRABILITY OF EXTENDED CAPABILITY

In summary, the advantages of extended flight duration are more clearly seen from the perspective of an advancing sequence of flights and missions. The early flights are characteristically those basic investigations and precursor activities leading to the more sophisticated approaches of the future.

Table 4-2 lists for each of the 50 payloads, from the scientific or technological point of view, the desired flight duration for the operational phase missions; that is, if the SSPDA 7-day flights are most desirable during what is considered the research and development activity periods, then the Table 4-2 durations represent flight periods of interest during the operational phases of the mission. The operational phase flight duration requirements also reflect the transition to advanced activities aimed at producing substantially more results and heavier work loads on a more tightly programmed and/or routine basis. Earlier flights during the R&D period would concentrate on proving methods and procedures as well as undertaking basic scientific and technological investigations (seed studies) which would serve as precursor

[5] Definition of Experiment and Instruments for a Communication/Navigation Research Laboratory (NASA 8-27540)

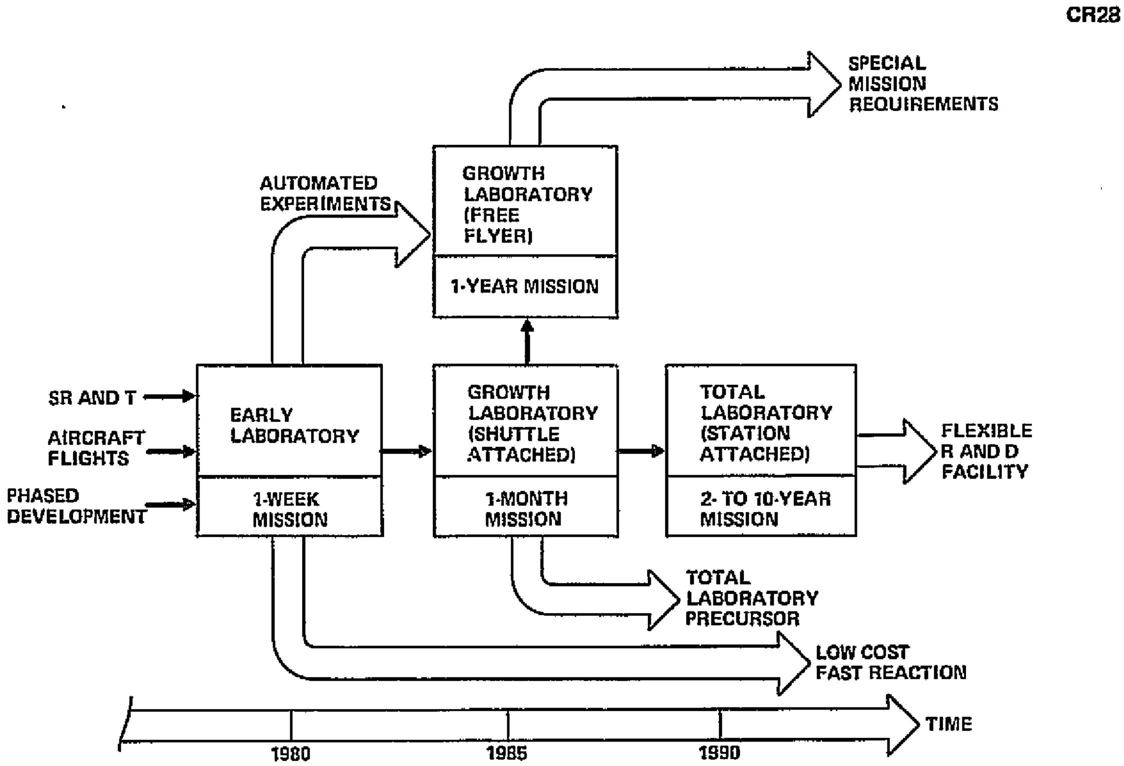

Figure 4-3. Possible Time Phasing for Future Options

activities to the larger scale operations later in the program. Similarly, research plans could be scheduled is a less structured and more flexible manner allowing for on-orbit adjustments to cope with the unexpected. Likewise longer observation periods would permit larger quantities of data to be acquired, especially where measurements are made of signals in the presence of noise and where rare occurrences in nature are being studied. Because of the statistical techniques employed in the analysis and interpretation of these classes of observations, any improvement which offered an increase in data quality would be particularly attractive.

Also included in Table 4-2 is a sampling of the type of emphasis that the operational phase might address during the MOSC era. For example, the Earth observations, Earth and ocean physics, communications/navigation and certain of the space technology payloads might be involved in a large-scale international program of coordinated research patterned after the International Geophysical Year — 1957/1958 as noted by IGY in the emphasis column.

Table 4-2

DESIRED FLIGHT DURATIONS FOR LATER OPERATIONAL PHASES

SSPDA Payload	Up to 30 Days	30 to 60 Days	60 to 90 Days	1 Year and Longer	Typical Emphasis
AS-01-S		•			Survey, discrete sources
AS-03-S		•			Survey, whole sky
AS-04-S		•			Survey, discrete sources
AS-15-S		•			High resolution faint sources
HE-X-S		•			Isotopic abundances and spectra
SO-01-S			•		3 synoptic solar resolutions 1GY
AP-06-S			•		1GY
EO-01-S		•			Expanded test protocol
EO-05-S			•		1GY
EO-06-S			•		1GY
EO-07-S			•		1GY
OP-02-S			•		1GY
OP-03-S			•		1GY
OP-04-S			•		1GY
OP-05-S			•		1GY
OP-06-S			•		1GY
SP-14-S		6 months extended processing			
LS-X-S				•	Adaptation of several generations
ST-21-S			•		1GY
CN-02-S			•		1GY
AS-08-S		•			Survey, whole sky
AS-10-S		•			Survey, whole sky
AS-13-S			•		3 continuous solar revolutions 1GY
AS-19-S		•			Survey, whole sky
AS-31-S		•			Survey, whole sky
AS-54-S		•			Survey, whole sky
AS-01-R	7 days				Revisit
HE-14-S		•			Survey synoptic
HE-19-S		•			Survey synoptic
HE-11-R	7 days				Revisit
SP-04-S	•				Production processes
SP-05-S	•				Prototype tests
SP-15-S	6 months				Pilot production
SP-16-S	•				Pharmaceuticals
SP-19-S	6 months				Pilot production
SP-1X-S			•		Space manufacturing operations
SP-2X-S			•		Space manufacturing operations
SP-3X-S			•		Space manufacturing operations
SP-4X-S			•		Space manufacturing operations
LS-04-S	Not applicable				Teleoperator
LS-09-S				•	Response and adaptation
LS-10-S	Not applicable				Carry-on
ST-04-S		•			Advanced tests
ST-05-S		•			Advanced tests
ST-06-S		•			Advanced tests
ST-08-S	Not applicable				Contamination monitor
ST-22-S			•		IGY
ST-23-S			•		IGY
CN-04-S			•		IGY
CN-06-S			•		IGY

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Most notably in the Life Sciences discipline area extended capabilities in terms of large payloads and laboratory facilities coupled with greatly increased flight duration over that available on Spacelab offers a vastly expanded dimension to the research potential offered by a MOSC. This research area and many similar ones that can be studied in a MOSC have direct relationships to immediate needs of mankind on Earth. For example, increased understanding of the growth phenomenon of living organisms can assist directly in the establishment of more precise nutritional requirements; aberrations in cell division observed in space may be of direct importance in cancer research; the manufacture in a weightless environment of extremely pure pharmaceuticals and materials with unique properties with significant interest to the fields of health and economic benefits to mankind.

4.9 REFERENCES

1. The Proceedings of the Skylab Life Sciences Symposium, Volumes I and II, NASA Technical Memorandum TM X-58154 (JSC-09275), dated November 1974, pp. 307-339.

2. Halide Eutectic Growth, A. S. Yue and J. G. Yu, UCLA, pp. 469-489, Proceedings Third Space Processing Symposium, Vol. 1, MSFC Report M-74-5, June 1974.

3. Vapor Growth of GeSe and GeTe Single Crystals in Microgravity, H. Wiedemeier, F. C. Klaessig, S. J. Wey, and E. A. Irene, Rensselaer Polytechnic Institute, pp. 235-256, ibid.

4. Preparation Electrophoresis of Living Lymphocytes, C. J. Van Oss, P. E. Bigazzi, C. F. Gillman, School of Medicine, State University of New York and R. F. Allen, MSFC, pp. 755-762, ibid.

5. Definition of Experiment and Instruments for a Communication/Navigation Research Laboratory (NASA 8-27540).

6. Reference Earth Orbital Research and Applications Investigation, NHB 7150.1, NASA, January 15, 1971.

Section 5
MISSION/PAYLOAD CONCEPTS

The 46 payloads considered candidates for MOSC class missions were grouped into 19 compatible combinations. The grouping was accomplished based upon similar needs of the scientific investigations and application activities in space. The combinations consist of those payloads which could be carried on the same flight and as such would have similar orbital requirements and be compatible from the operational point of view. Table 5-1 lists the 19 combinations, their corresponding SSPDA or other composition and their general characteristics. Table 5-2 lists the payload characteristics for each of the combinations.

The following discussion covers each of the 19 combinations in turn.

Combination C-1, IR Astronomy

1. Two 40-day flights will provide the time necessary to gather the required IR information from stars, nebulae, galaxies and planets. The second flight, six months after the first, will provide for gathering information from positions 180° apart in the Earth's orbit around the sun, allowing views of the entire celestial sphere.

   Forty-day flights will help keep launch weights down in that the payload contains sensors that are cryogenically cooled. Extended flights would require the launching of larger quantities of cryogens or resupply.

2. The orbit plane is not a constraint on payload operation, and a 28.5° inclination is acceptable. The altitude must be sufficient to insure that atmospheric effects are minimized, and altitude range of 160 to 260 nmi is acceptable with 216 nmi preferred.

Table 5-1

MOSC COMBINED PAYLOADS COMPOSITION AND DESCRIPTIONS

MOSC Payload Ident	SSPDA (or other) Payloads Included (see notes)	Research and Application Areas Addressed	Driving Requirements and Critical Characteristics
C-1	AS-01-S, AS-15-S	IR Astronomy	Precision pointing and vibration free
C-2	AS-03-S, AS-04-S, AS-08-S, AS-10-S	UV Astronomy	Contamination and disturbance free
C-3	SO-01-S, AS-13-S	Solar Observ	60-day continuous observation
C-4	AP-06-S, CN-02-S (1)	Space Sci No. 1	High levels of onboard activity
C-5	AP-06-S, CN-04-S, CN-06-S (1)	Space Sci No. 2	High levels of onboard activity
C-6	AP-06-S, EO-07S, OP-05-S (1)	AMPS/Earth Sci	Onboard data management by crew
C-7	SP-14-S, ST-04-S, ST-05-S	Space Technology	Low microgravity (>10^{-4} G), high power
C-8	EO-01-S, ST-21-S, ST-22-S	Cloud Phys/Tech	Crew involvement for extended periods
C-9	EO-05-S, OP-02-S (2), OP-06-S (1)	Earth Sci No. 1	Onboard data management by crew
C-10	EO-05-S, EO-06-S, OP-03-S, OP-04-S (1)	Earth Sci No. 2	Onboard data management by crew
C-11	AS-19-S, HE-14-S, HE-19-S, ST-06-S	HE Astro/Tech	Contamination free environment
C-12	SP-04-S, SP-05-S, SP-16-S, LS-09-S, LS-10-S (1)	Life Sci/Matl Tech No. 1	Deep crew involvement, high power
C-13	SP-15-S, SP-19-S, LS-09-S, LS-10-S (1)	Life Sci/Matl Tech No. 2	Deep crew involvement, high power
C-14	AS-31-S (3)	IR/UV Astronomy	Contamination, precision pointing
C-15	AS-54-S (3)	UV Astronomy	Contamination free environment
C-16	HE-X-S (3)	Cosmic Ray Lab	High power, massive payload
C-17	LS-X-S (3)	LD Life Sci Lab	Very long flight duration (>1 year)
C-18	ST-23-S	Adv Technology	Deep crew involvement
C-19	SP-X5-S (4)	Space Manuf	High power, low disturbances

NOTES:
(1) SSPDA payloads appearing in more than one combination reflect the requirements for more frequent flights or extended mission periods.
(2) Equipment requirements for OP-02-S and OP-05-S are identical and therefore only OP-02-S is listed.
(3) These payloads constitute major dedicated facilities or payloads already grouped.
(4) Combination of preliminary space manufacturing payloads SP-X1-S, SP-X2-S, SP-X3-S and SP-X4-S. General: The LST and HEO revisits (AS-01-R, HE-11-R) not included, payloads ST-08-S and LS-04-S were considered to be operational support equipment by 1984 and therefore not included.

Table 5-2

SELECTED CHARACTERISTICS OF MANNED ORBITAL FACILITY PAYLOAD COMBINATIONS

ID No.	Payload Description	Initial Weight klb (10^3 Kgm)	Return Weight klb (10^3 Kgm)	Payload Volume 100 ft^3 ($100m^3$)	Mission[1] Duration (days)	Crew Support (mnhr)	No. of Flights
1	IR Astronomy	31 (14)	25 (11)	45 (1)	80	1454	2
2	UV Astronomy	24 (11)	14 (6)	11 (3.3)	140	3845	2
3	Solar Observ	15 (7)	14 (6)	10 (3,	160	4187	4
4	Space Sci No. 1	17 (8)	15 (7)	27 (1)	70	2070	2
5	Space Sci No. 2	16 (7)	12 (5)	22 (1)	80	1608	2
6	AMPS/Earth Sci	24 (11)	14 (6)	19 (1)	120	3280	2
7	Space Technology	26 (12)	17 (8)	23 (1)	40	884	1
8	Cloud Phys/Tech	15 (7)	13 (6)	20 (1)	50	882	1
9	Earth Sci No. 1	25 (11)	24 (11)	61 (2)	50	851	2
10	Earth Sci No. 2	26 (12)	26 (12)	60 (2)	80	690	2
11	HE Astro/Tech	20 (9)	20 (9)	12 (0.3)	70	1118	2
12	Life Sci/Matl Tech No. 1	100 (45)	66 (30)	133 (4)	400	8289	4
13	Life Sci/Matl Tech No. 2	81 (36)	60 (27)	106 (3)	200	4039	2
14	IR/UV Astronomy	45 (20)	17 (8)	20 (1)	120	1427	2
15	UV Astronomy	24 (11)	16 (7)	10 (0.3)	50	585	2
16	Cosmic Ray Lab	50 (23)	37 (17)	56 (2)	360	5800	1
17	LD Life Sci Lab	39 (18)	34 (15)	26 (1)	720	23200	1
18	Adv Technology	8 (4)	7 (3)	16 (0.5)	45	493	1
19	Space Manuf	7 (3)	6 (3)	2 (0.1)	900	11000	10
					3735	75702	45

[1]Flight Duration = $\frac{\text{Mission Duration}}{\text{No. of Flights}}$

Combination C-2, UV Astronomy

1. A combination of two 70-day flights will be required to acquire UV information for this combination. The initial flight will provide one-half the basic data. A second flight, 6 months after the first, will provide for gathering the remainder of the information from positions 180° apart in the Earth's orbit.

2. The orbit plane is not a constraint on payload operation, but the altitude must be sufficient to insure that atmospheric effects are minimized; an altitude range of 240 to 250 nmi is acceptable with 248 nmi preferred.

Combination C-3, Solar Observation

1. Four 40-day flights provide sufficient coverage of four complete revolutions of the sun. Extended flights (i. e., 60 days) will provide for coverage over multiple revolutions and also obtain information on solar phenomena. Spacing and scheduling of flights over the fundamental and several harmonics of the sun activity cycle (11 years) provides information during quiet and active solar periods.

2. The orbit plane is not critical to any of the solar observing instruments. The altitude range of 190 to 220 nmi is acceptable with 216 nmi preferred.

Combination C-4, Space Science No. 1

1. Flights of 35-day duration are desirable for the AMPS remote sensors to provide coverage of the Earth's atmosphere under varying conditions as well as sufficient time to overfly several times specific geographical areas which are sources of terrestrial noise. A series of two flights will provide additional information with relation to natural externally produced radiation, such as increased or decreased solar activity.

2. Observations at both high and low latitude of the Earth's atmosphere, magnetosphere and for performing plasma physics investigations.

The communications/navigation sensor desire a minimum of 60° inclination. An altitude range of 212 to 270 nmi is acceptable with 215 nmi preferred. However, the polar orbit could satisfy both the AMPS measurements and the higher latitude requirements of communication/navigation. Therefore, the polar orbit is preferred as being universal in meeting the needs of the combined observation program.

Combination C-5, Space Science No. 2

1. The combination is a counterpart to C-4, with the AMPS instrumentation repeated but including a different complement of communications experiments. Two 40-day flights are desirable to provide coverage of the Earth's atmosphere under as varying conditions as possible. A series of flights will provide additional information concerning noise sources and tests of communications relay equipment under varying conditions.

2. As stated above earlier, the polar orbit is preferred for C-4. An altitude range of 212 to 245 nmi is acceptable with 216 nmi preferred.

Combination C-6, AMPS/Earth Science

1. Two 60-day flights are of sufficient duration to obtain data, in addition to AMPS, on the Earth's atmosphere and weather conditions over an extended period of time. A series of flights will provide additional information gathered during selected two month intervals of the Earth's seasonal cycle.

2. Polar orbit is required to obtain maximum coverage of the Earth's surface. An altitude range of 200 to 210 nmi is acceptable with 200 nmi preferred.

Combination C-7, Space Technology

1. One 40-day flight could satisfy the requirements of this payload. It should be noted that these are research applications for this discipline and not the pilot, prototype or operations contemplated in the processing

facility of Combination C-19. The 40-day flight will provide sufficient time to (1) manufacture a quantity of material to support planned ground usage and (2) perform the technological studies planned and modify tests to produce desired information.

2. Orbit parameters are not critical for this payload; a 28.5° inclination and an altitude range of 100 to 350 nmi is acceptable with 200 nmi preferred.

Combination C-8, Cloud Physics/Technology

1. The mission of this payload is to obtain data on the Earth's climate conditions over an extended period of time. During this era, the cloud physics laboratory would no longer be a development unit and the final configurations would have been identified. Longer durations would provide sufficient time to perform planned operations and to modify tests to produce desired information. The flights will provide additional information during the Earth's seasonal cycle.

   A 50-day flight will provide the on-orbit payload time required by the PI.

2. Orbit parameters are not critical and a 28.5° inclination is satisfactory. An altitude range of 100 to 300 nmi is acceptable, with 100 nmi preferred.

Combination C-9, Earth Science No. 1

1. Two 25-day flights are desirable to provide multiple passes over the Earth's surface and to provide seasonal coverage of climatic conditions. The series of flights will provide additional information during the Earth's annual cycle.

2. Altitude considerations indicate that a range of 200 to 210 nmi is acceptable with 200 nmi preferred. A polar orbit will provide for maximum coverage of the Earth's surface.

Combination C-10, Earth Science No. 2

1. This payload is a counterpart of C-9. Two 40-day flights are desirable to provide multiple passes over the Earth's surface to minimize data loss caused by local and regional adverse conditions. The weather flights will provide additional information during specifically significant and selected portions of the Earth's seasonal cycle.

2. An altitude range of 200 to 210 nmi is acceptable with 200 nmi and a polar orbit preferred.

Combination C-11, HE Astronomy/Technology

1. Two 35-day flights will provide the time necessary to gather energy information from stellar and intergallactic regions. The second flight, six months after the first, will provide for gathering information from positions 180° apart in the Earth's orbit.

2. An inclination of 28.5° is desired for this combination. An altitude of 135 nmi is recommended based upon the following considerations: The MOSC combination payload C-11 comprises four scientifically compatible SSPDA Sortie payloads: AS-19-S, Selected Area Deep Sky Survey Telescope; AE-14-S, Gamma Ray Pallet; HE-19-S, Low Energy X-Ray Telescope; and ST-05-S, Fluid Physics Plus Heat Transfer (Facility No. 3). The altitude constraints as described in the SSPDA for ST-06-S are any altitude above 186 km. HE-14-S and HE-19-S indicate maximum altitudes of 237 and 245 km, respectively. The altitude requirements for AS-19-S specify a minimum of 250 km. The logical combination of the four separate payloads, as far as altitude is concerned, is compromised at 250 km (135 nmi). The two high-energy cosmic ray astrophysics payloads (HE-14 and HE-19) have maximum altitude and maximum inclination constraints. These requirements are typical of this class of payload where the precipitation and background radiation from trapped particles in the lower regions of the Van Allen belt are to be avoided. As for the AS-19 astronomy payload, the minimum altitude requirements stem from the consideration that any portion of the atmosphere could hinder observations in the far ultraviolet region of the spectrum.

A polar orbit is preferred to provide additional coverage not offered to C-1 and C-2 where 28.5° inclinations are indicated. The altitude range acceptable is 130 to 220 nmi, with 162 nmi preferred.

Combination C-15, UV Astronomy

1. Two 25-day flights are desirable to obtain both survey and narrow field UV information from stellar and intergallactic sources. The two flights, separated by six months, will provide for gathering information from positions 180 apart in the Earth's orbit. The mission should be scheduled a year or two after C-2 since it is supplemental to the C-2 mission.

2. As cited above a polar orbit with an altitude of 130 to 220 nmi is acceptable, with 162 nmi preferred.

Combination C-16, Cosmic Ray Lab

1. A single flight of 360 days' duration is most desirable for this payload. This duration would provide for a statistically significant number of cosmic ray events of the rarely encountered species to be recorded.

2. An inclination of 28.5° and an altitude range of 150 to 250 nmi is acceptable, with 200 nmi preferred.

Combinatio C-17, LD Life Science Laboratory

1. This is a long-duration lab with a flight time of two years. This flight period would be desirable, as its mission would be scheduled subsequent to the precursor 100-day and possibly longer periods of C-12 and C-13. Combination C-17 activities emphasize long-term adaptable of organisms to the environment of space.

2. The orbit is not critical and a 28.5°, 200 nmi altitude circular orbit would be satisfactory.

Combination C-12, Life Science/Materials Technology No. 1

1. This combination contains life science payloads which require extended flight durations (greater than 60 days) and space processing payloads which can be satisfied by shorter periods but would benefit economically by extended durations. The life science laboratory and its associated investigations included in this combination is particularly suited for a 100-day flight. Four 100-day flights will be required to satisfy the activities scheduled for this combination.

2. The orbit plane is not critical for this combination. An altitude range of 150 to 350 nmi is acceptable, with 200 nmi preferred. A 28.5° orbit is satisfactory.

Combination C-13, Life Science/Materials Technology No. 2

1. This payload is a counterpart to C-12. Two 100-day flights will provide sufficient exposure to complete the life science investigation begun in C-12.

2. The orbit plane is not critical for this combination. An altitude range of 100 to 350 nmi is acceptable, with 200 nmi preferred. A 28.5° orbit is satisfactory.

Combination C-14, IR/UV Astronomy

1. Two 60-day flights will provide the time necessary to gather the required correlated multispectral information from stars, nebulae, galaxies, and planets. The second flight, six months after the first, will provide for gathering information from positions 180° apart in the Earth's orbit. This combination, which would fly several years after C-1 and C-2, is complementary to C-1 and C-2 and is planned to fill gaps in the coverage of the earlier missions and benefit from instrument improvements and should be scheduled for a later period in the MOSC era. Flights at 60 days' duration also keep launch weights down as compared to a single mission of longer duration. One of the payloads in this combination contains sensors that are cryogenically cooled; therefore, extended flights will require the launching of massive quantities of cryogens.

Combination C-18, Advanced Technology

1. One 45-day flight would be adequate to accomplish the activities and to provide the crew support necessary to satisfy the technical objective of these payloads.

2. Polar orbit is highly desirable because of maximum coverage of the Earth's surface by the advanced sensors being evaluated. An altitude range of 100 to 300 nmi is acceptable, with 200 nmi preferred.

Combination C-19, Space Manufacture

1. This production facility should be flown annually with a duration of 90 days.

2. Since one of the production facilities was a solar collector furnace, a polar orbit or sun-synchronous inclination is desirable with an altitude range of 200 to 300 nmi acceptable, and 200 nmi preferred.

In the area of crew skills and manpower requirements each payload and payload group were re-examined and the crew skills defined in accordance requirements spelled out in the Level B SSPDA using standardized categories as listed and referenced in the ESSEX Corporation report, Role of Man in Flight Experiment Payload Missions, dated August 1973. An assessment of the crew requirements suggests that for 60- or 90-day flight durations, adequate support can be achieved by the assignment of two to four crewmen, provided that adequate cross training has been accomplished. This conclusion is based upon the number of experiment manhours accumulated as a function of flight duration compared to the total payload manpower requirements. In addition, a statistical treatment of the payload/crew skills requirements has led to possible multidiscipline and interdiscipline assignments as described below.

Appendix C contains the computational results of analyzing the payload crew assignments by means of a factor analytic technique. For the 46 SSPDA class payloads investigated there were 15 skills, as defined by the standardized terminology, required to satisfy the needs of the payloads. These skills are identified in Appendix C along with the number of times,

on the average, that each skill appeared as a requirement. The factor analysis solution led to the identification of six new specialities or multidiscipline/interdiscipline assignments which could have favorable impacts on crew selection and training criteria.

In addition, it was determined that a seventh skill, in this case that of an astronomer, would be required to fill out a complementary grouping of new skills across the 46 payloads. Table 5-3 lists these six skill groupings along with their composition in terms of the original 15 skills as related to the standardized definitions.

Figure 5-1 describes the relationships between the manpower and mission duration requirements for each of the 19 MOSC payloads. The family of curves representing mission durations of from 50 to 1000 days was calculated using a factor of eight hours per day per crewman available for payload operation and allowing one day in seven as a day when no work would be scheduled (a day off). Improvement in onboard performance as a function of time in orbit was based upon an 85 percent learning curve as discussed in Section 3. These factors are substantially the same as were observed in the Skylab mission operations. The points shown on the figure are plots of required manhours versus mission duration for each of the 19 payloads. It may be seen that a crew size of four appears sufficient, with two exceptions, to meet the demands of the 19 payloads under varying conditions of mission duration and workloads. The payload combinations C-4 and C-17, as shown in the figure, exceed by a small extent the crew size of four. However by extending the flight period for C-4 slightly (from 35 days to 38 days) the required manpower would be available. For combination C-17, the manpower requirement of 23,200 manhours would require about 846 days to accumulate (as contrasted to the desired 720-day flight duration). Considering the very long flight duration called for by C-17 and the preliminary nature of the estimated requirement for 23,200 manhours, there is a question and an uncertainty as to the adequacy or inadequacy of the four-man crew to satisfy these requirements. Further definition of this payload is required before the establishment of the exact crew size is justified. Furthermore, no payload group (see Appendix C) required more

Table 5-3

CREW SKILLS COMBINATIONS

No. of Combos Using	Newly Defined Skill Combination		Individual Skills Standardized Nomenclature	No. of Payloads Using Skill
	I. D.	Description		
3	A	Earth Sciences Specialist	Geologist	5
			Oceanographer*	8
			Agronomist	3
			Geographer	4
3	B	Life Sciences Specialist	Medical Doctor	1
			Behavioral Scientist	3
			Biologist*	3
4	C	Meteorologist/Photographer	Photo Technician	3
			Meteorologist*	3
5	D	Materials Sciences Specialist	Biochemist	2
			Metallurgist/Chemist*	12
7	E	Physical Sciences Specialist	Electronics Engineer	7
			Physicist*	7
19	F	Engineering Technician	Electromechanical/ Optical Technician	29
6	G	Astronomical Sciences Specialist	Astronomer/Astrophysicist	14

(1) Crew skill classification scheme currently used in Sortie Lab Program
* Indicate prime or lead skill

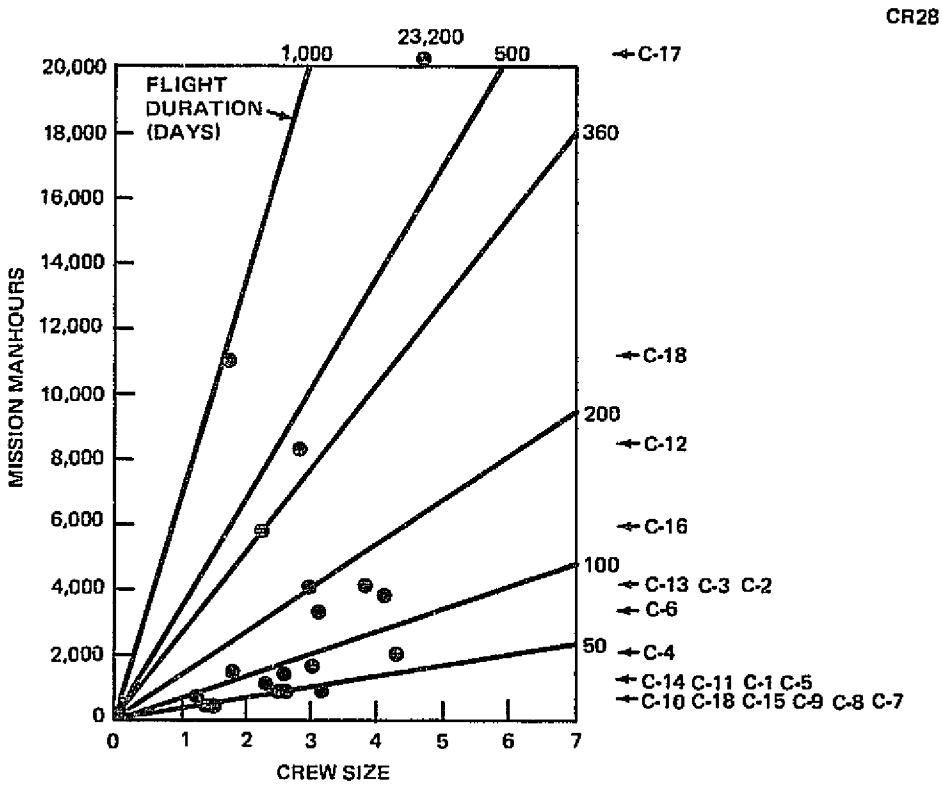

Figure 5-1. Crew Sizing

than four of the skill categories identified. When this finding is considered along with the manhour requirements of the payload groups, it would appear that a four-man crew size should represent the nominal or baseline case to use in the configuration sizing activity.

Section 6
PRELIMINARY DESIGN AND OPERATIONAL REQUIREMENTS

6.1 OPERATIONAL REQUIREMENTS

The operational requirements and physical characteristics of the 19 combinations of payloads considered for MOSC are summarized in Table 6-1. The data in the column labeled "Orbit Altitude" is a summarization of the desired operational altitude for each of the 19 payload combinations. These data were arrived at by assessing the needs of each individual payload and its requirements, which made up each combination. Where several ranges of altitude requirements were indicated as acceptable the desired altitude was taken, in general, as the lowest value that would satisfty the needs of each individual member of the combination. The range of acceptable altitudes as well as the desired altitudes for each combination was used further in the study to establish the nominal and polar orbit MOSC operational altitudes of 200 nmi. The selection rationale for the baseline altitude is presented in Book 3 of this report.

The characteristics of the 19 payloads have been arranged in order according to (1) ascending payload weights, (2) initial calendar year desired for operating capability, and (3) required orbital inclinations. The ordering of the payload combinations for these three parameters is shown in Tables 6-2, 6-3, and 6-4, respectively. The data arrangement in Table 6-4 clearly shows that the requirements dictate both a polar orbiting facility (nine payloads) as well as a facility located in a nominal 28.5° inclination. The operational implications of these data suggest that both the ETR and the WTR will be required to support MOSC missions.

As discussed previously the 19 payload combinations are made up of 46 individual payloads. In the Level A sheets of the SSPDA, the desired payload use per year is indicated. Correlating these payloads to the October 1973 Space Shuttle Traffic Model results in the schedule, shown in Table 6-5, for Shuttle launches to accommodate these payloads on the Spacelab seven-day

Table 6-1

MOSC PAYLOAD COMBINATION CHARACTERISTICS AND REQUIREMENTS

		Desired Mission and Flight Parameters							Physical Characteristics				Skills
Ident. No.	No. of SSPDA 7-Day Flights	Experiment Crew Time, man-hours	IOC	No. of Flights	Flight Duration, days	Crew Size, people	Orbit Altitude, nmi (km)	Orbit Inclination, degrees	Up Weight, klb (10^6 g)	Volume, 100 ft^3 (100 m^3)	Average Power, kW	Energy, kWh	Combo Skills Req'd*
C-1	17	1,454	1984	2	40	3	216(400)	28	31(14)	45(1)	1	1,112	FGG
C-2	131	3,845	1985	2	70	4	248(460)	28	24(11)	11(0.3)	1	998	FFGG
C-3	212	4,187	1988	4	40	4	216(400)	28	15(7)	10(0.3)	1	241	FFGG
C-4	15	2,070	1986	2	35	4	216(400)	90	17(8)	27(1)	2	2,008	EEFF
C-5	17	1,608	1986	2	40	3	216(400)	90	16(7)	22(1)	2	1,615	EEF
C-6	36	3,280	1986	2	60	4	200(370)	90	24(11)	19(1)	2	3,270	ACEF
C-7	40	884	1985	1	40	4	200(370)	28	26(12)	23(1)	10	2,801	DDEF
C-8	15	882	1988	1	50	3	100(185)	28	15(7)	20(1)	1	850	CEF
C-9	31	851	1987	2	25	3	200(370)	90	25(11)	61(2)	2	874	ACF
C-10	31	690	1987	2	40	3	200(370)	90	26(12)	60(2)	2	1,079	ACF
C-11	36	1,118	1987	2	35	3	135(250)	28	20(9)	12(0.3)	1	704	DFG
C-12	35	8,289	1986	4	100	4	200(370)	28	100(45)	133(4)	10	20,509	BBDF
C-13	28	4,039	1986	2	100	4	200(370)	28	81(36)	106(3)	6	21,265	BBDF
C-14	15	1,427	1988	2	60	2	162(300)	90	45(20)	20(1)	2	1,581	FG
C-15	5	585	1989	2	25	2	162(300)	90	24(11)	10(0.3)	1	689	FG
C-16	Not SSPDA	5,800	1990	1	360	2	200(370)	28	50(23)	56(2)	1	8,640	EF
C-17	Not SSPDA	23,200	1992	1	720	4	200(370)	28	39(18)	26(1)	8	94,800	BBFF
C-18	6**	493	1988	1	45**	2	200(370)	90	8(4)	16(0.5)	2	857	EF
C-19	Not SSPDA	11,000	1990	10	90	2	200(370)	90	7(3)	2(0.1)	5	20,000	DF

*See Table 5-3 for multidiscipline skills mix.

**The original SSPDA Level A data sheets estimate that 782 crew mission hours will be required to satisfy the requirements of this payload. With a crew of two, and factoring in the learning expected to be experienced with longer flight durations, this requirement can be fulfilled by a single flight of 45-days duration.

Table 6-2

PAYLOADS SORTED ACCORDING TO INCREASING TOTAL WEIGHT

Payload		Initial Weight lb (10^6 g)	Volume ft^3 (m^3)
Space Manufacturing	(C-19)	7,000 (3)	200 (6)
Adv Technology	(C-18)	8,000 (4)	1,600 (46)
Solar Observ	(C-3)	15,000 (7)	1,000 (29)
Cloud Phys/Tech	(C-8)	16,000 (7)	2,000 (57)
Space Sci No. 2	(C-5)	16,000 (7)	2,200 (63)
Space Sci No. 1	(C-4)	17,000 (8)	2,700 (77)
HE Astro/Tech	(C-11)	20,000 (9)	1,200 (34)
UV Astronomy	(C-2)	24,000 (11)	1,100 (31)
AMPS/Earth Sci	(C-6)	24,000 (11)	1,900 (54)
UV Astronomy	(C-15)	24,000 (11)	1,000 (29)
Earth Sci No. 1	(C-9)	25,000 (11)	6,100 (17[illegible])
Space Technology	(C-7)	26,000 (12)	2,300 (66)
Earth Sci No. 2	(C-10)	26,000 (12)	6,000 (171)
IR Astronomy	(C-1)	31,000 (14)	4,500 (129)
LD Life Sci Lab	(C-17)	39,000 (18)	2,600 (74)
IR/UV Astronomy	(C-14)	45,000 (20)	2,000 (57)
Cosmic Ray Lab	(C-16)	50,000 (23)	5,600 (160)
Life Sci/Matl Tech No. 2	(C-13)	81,000 (36)	10,600 (303)
Life Sci/Matl Tech No. 1	(C-12)	100,000 (45)	13,300 (380)

flight program. A total of 58,472 manhours is required to support payload activity in the 7-day flight period sortie mode of operation for the above flights, not including the manpower requirements for C-16, C-17 and C-19. For these three payloads the manpower requirements were estimated for a MOSC mode of operation and equate to 40,000 manhours.

Based on evaluation of Skylab data, it is suggested that an 85-percent learning curve for crew performance (see Figure 6-1) should be applied for longer flights. Consequently, the flight schedule constructed and shown in Figure 6-2 reflects the factoring in of this expected performance improvement.

Table 6-3

PAYLOADS SORTED ACCORDING TO INCREASE YEAR OF INITIAL OPERATING CAPABILITY DESIRED

Payload		IOC Year
IR Astronomy	(C-1)	1984
UV Astronomy	(C-2)	1985
Space Technology	(C-7)	1985
Space Sci No. 1	(C-4)	1986
Space Sci No. 2	(C-5)	1986
AMPS/Earth Sci	(C-6)	1986
Life Sci/Matl Tech No. 1	(C-12)	1986
Life Sci/Matl Tech No. 2	(C-13)	1986
HE Astro/Tech	(C-11)	1987
Earth Sci No. 1	(C-9)	1987
Earth Sci No. 2	(C-10)	1987
Adv Technology	(C-18)	1988
Solar Observ	(C-3)	1988
Cloud Phys/Tech	(C-8)	1988
IR/UV Astronomy	(C-14)	1988
UV Astronomy	(C-15)	1989
Space Manufacturing	(C-19)	1990
Cosmic Ray Lab	(C-16)	1990
LD Life Sci Lab	(C-17)	1992

This schedule takes into account an improved efficiency in available payload hours over what is required for the basic Spacelab 7-day flight program. The flight schedule also shows a reduced number of flights based on providing an equivalent payload program as defined for the basic Spacelab 7-day flight program. The total hours derived from sortie mode SSPDA descriptions required for the payload program has been reduced because of learning to about 35,702 hours. It should be noted that the preferred time on-orbit for most payloads has been modified to reflect the benefits from extended capability. Also note that three payloads (C-16, C-17 and C-19) should not be included in comparative launch requirements of the various modes, in

Table 6-4

PAYLOADS SORTED ACCORDING TO ORBITAL INCLINATIONS REQUIRED

Payloads Requiring 28.5° Orbits	
IR Astronomy	(C-1)
UV Astronomy	(C-2)
Solar Observ	(C-3)
Space Technology	(C-7)
Cloud Phys/Tech	(C-8)
HE Astro/Tech	(C-11)
Life Sci/Matl Tech No. 1	(C-12)
Life Sci/Matl Tech No. 2	(C-13)
Cosmic Ray Lab	(C-16)
LD Life Sci Lab	(C-17)
Payloads Requiring Polar Orbits	
Space Sci No. 1	(C-4)
Space Sci No. 2	(C-5)
AMPS/Earth Sci	(C-6)
Earth Sci No. 1	(C-9)
Earth Sci No. 2	(C-10)
IR/UV Astronomy	(C-14)
UV Astronomy	(C-15)
Adv Technology	(C-18)
Space Manufacturing	(C-19)

Table 6-5

SHUTTLE LAUNCHES FOR SSPDA SPACELAB SORTIE PAYLOADS

Year	80	81	82	83	84	85	86	87	88	89	90	91	
Shuttle Flights	Pre-MOSC				27	31	26	31	30	29	28	28	Total 229

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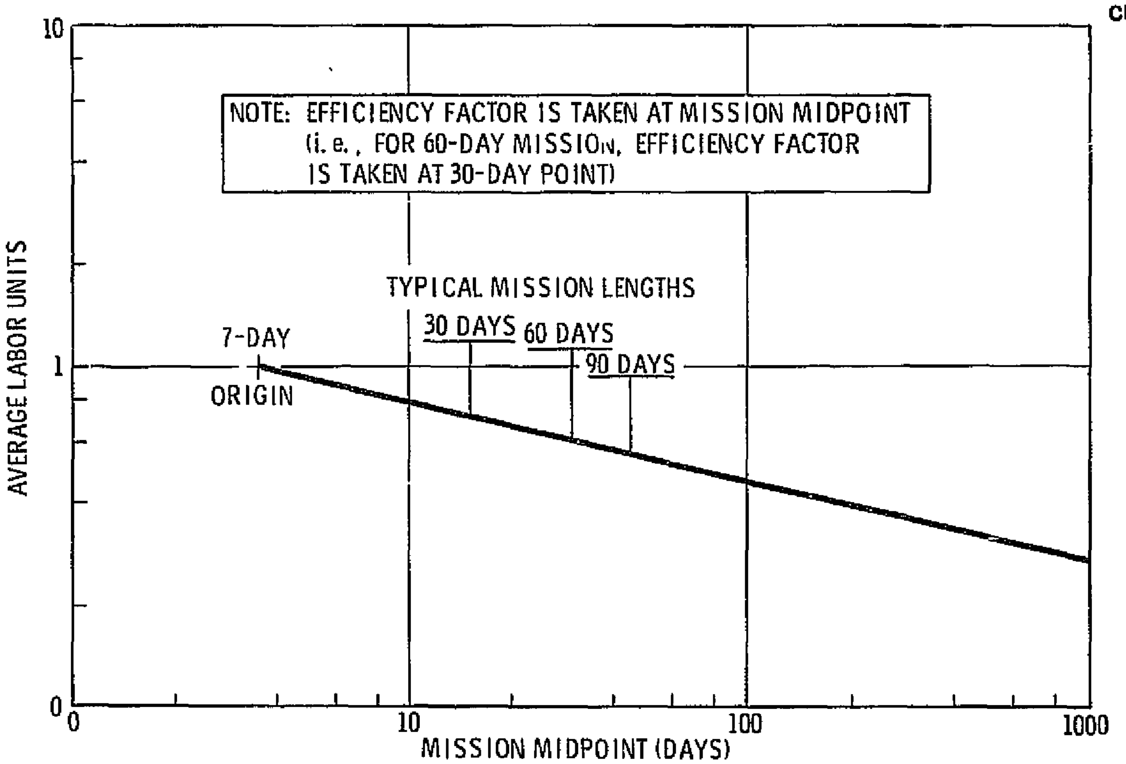

Figure 6-1. 85-Percent Learning Curve, Based on Skylab Data

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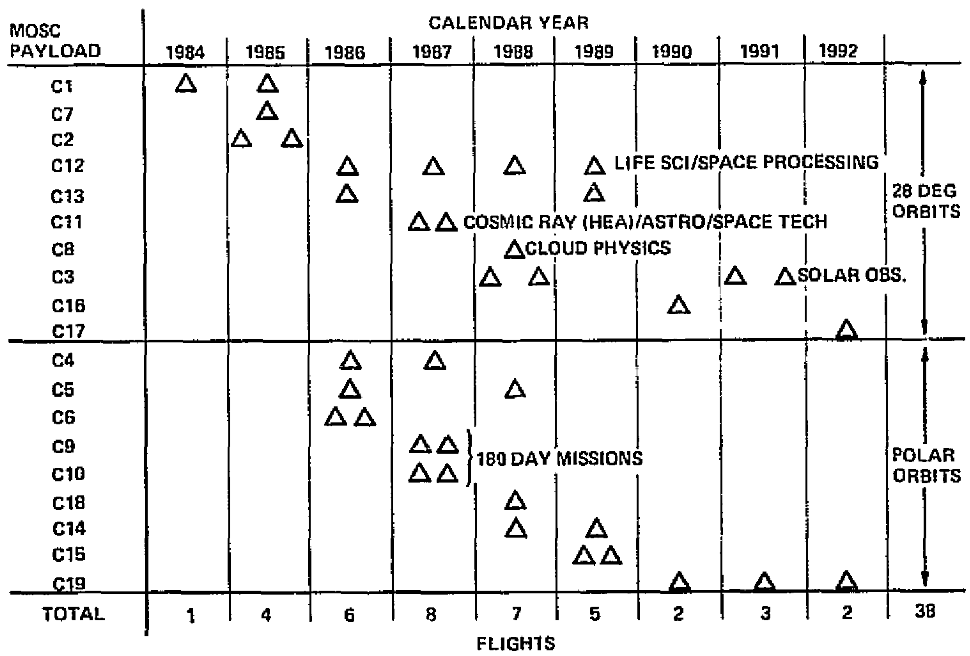

Figure 6-2. Typical MOSC Payload Flight Schedule

order to provide a consistent basis for comparison with the Spacelab. However, these payloads should be given consideration in the design and operations of a longer-duration research facility. The comparative figures excluding C-16, C-17, and C-19 support requirements indicate that about 58,472 hours of operation are required in the sortie mode versus about 35,702 hours for the MOSC mode of operation.

Two additional issues bearing upon mission operations and system design that were considered during the performance of this task included Earth viewing times from polar orbits and orbital decay as affected by drag. Since all of the Earth observations and Earth and ocean physics payload instruments prefer a polar orbit, the conditions that are encountered in these orbits were also examined.

Figure 6-3 portrays typical ground tracks that a MOSC would follow from a 200-nmi-altitude circular polar orbit. If land masses are to be observed, it can be seen from this figure that sequential viewing opportunities for overflying a given geographical area exist on a relatively few number of consec-

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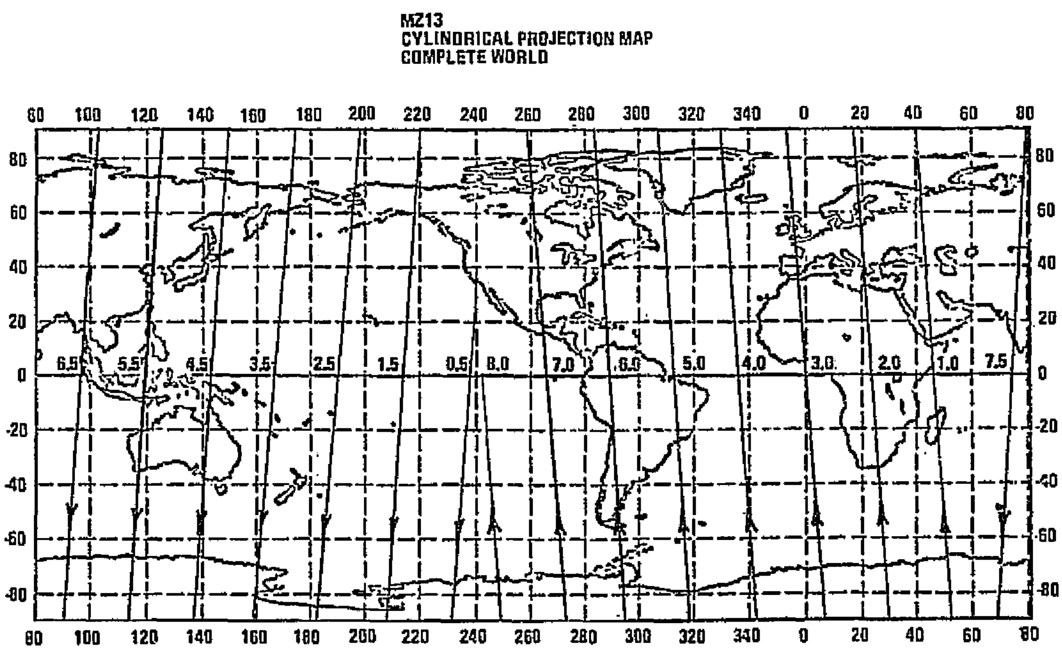

Figure 6-3. Typical Polar Orbit Trace (200-nmi Altitude)

utive revolutions. In the example shown, only three orbits occur consecutively to view North America below the spacecraft (Nos 6.0, 7.0, and 8.0). If these passes are made during the daylight, then the Asian land mass is overflown in the dark. Further, about 70 percent of the time the nadir of the spacecraft is on the surface of the ocean. When the requirements for specific lighting conditions (e.g., sun angle) and seasonal factors are considered the result is that only a relatively few number of revolutions during a flight are suitable for performing specific Earth observations.

Figure 6-4 is a plot of the orbital altitudes where subsynchronous ground track repetitions are encountered. The subsynchronous periods (days between exact ground track repeats) are shown along the abscissa of the chart with the corresponding circular polar orbital altitude plotted as the ordinate. If there is a specific requirement to overfly the same geographical point repeatedly then the selection of the orbital altitude can be made from these data. It is significant to note that if an altitude change capability were inherent in MOSC, a relatively small altitude adjustment can establish

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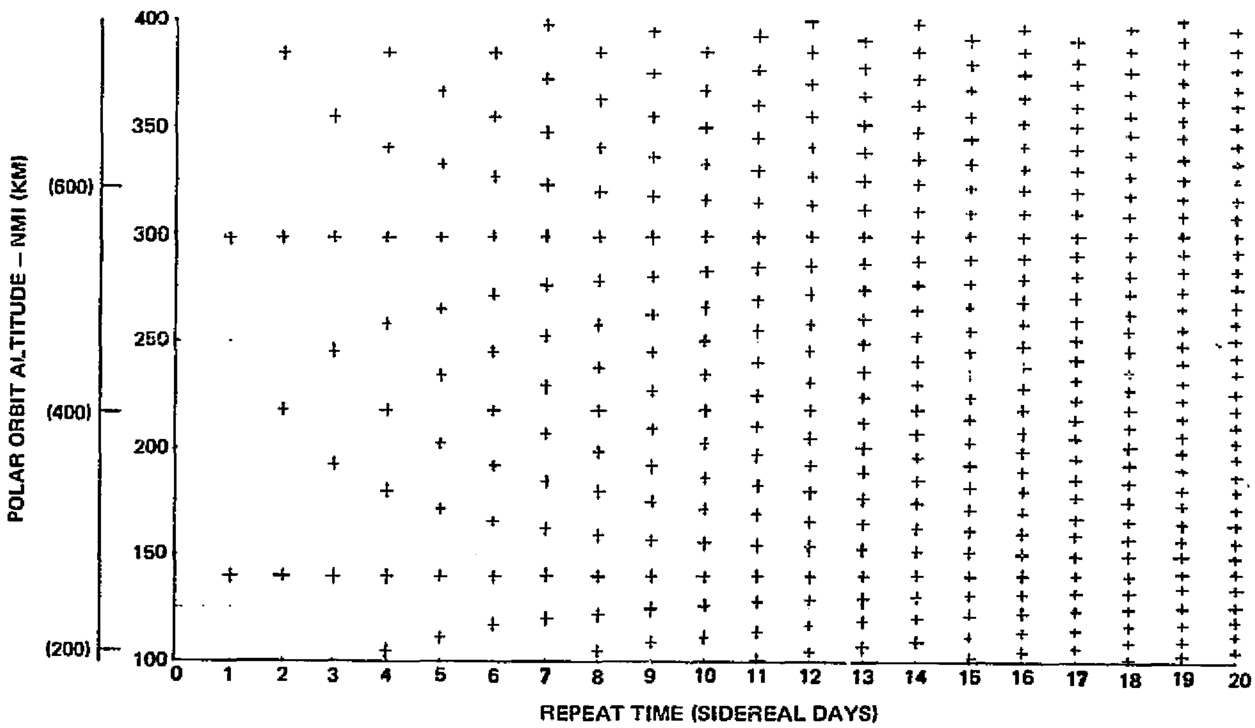

Figure 6-4. Orbit Trace Repetition

a variety of subsynchronous operations. For example, a nominal altitude of from 200 to about 210 nmi coincides with a five-day period. Maneuvering to an altitude of 295 nmi results in a daily repeat cycle. The impulse required for this maneuver can be determined from Figure 6-5.

Figure 6-6 plots the decay time, assuming merely the effects of aerodynamic drag on the spacecraft with solar cells deployed, to an orbital altitude of 100 nmi from various initial altitudes. For example, from a nominal 200-nmi altitude, it would take about 600 days to experience the decay to 100 nmi. Figure 6-7 which combines the relationships found in Figures 6-5 and 6-6 can be used in determining the amount of orbit-keeping impulse required to maintain specific circular polar orbit altitudes.

6.2 CARRIER REQUIREMENTS

Figures 6-8 through 6-13 are histograms of some of the more pertinent characteristics and carrier requirements of the 19 MOSC payload combinations. Portrayed are the (1) payload weight at lift off, (2) payload volume,

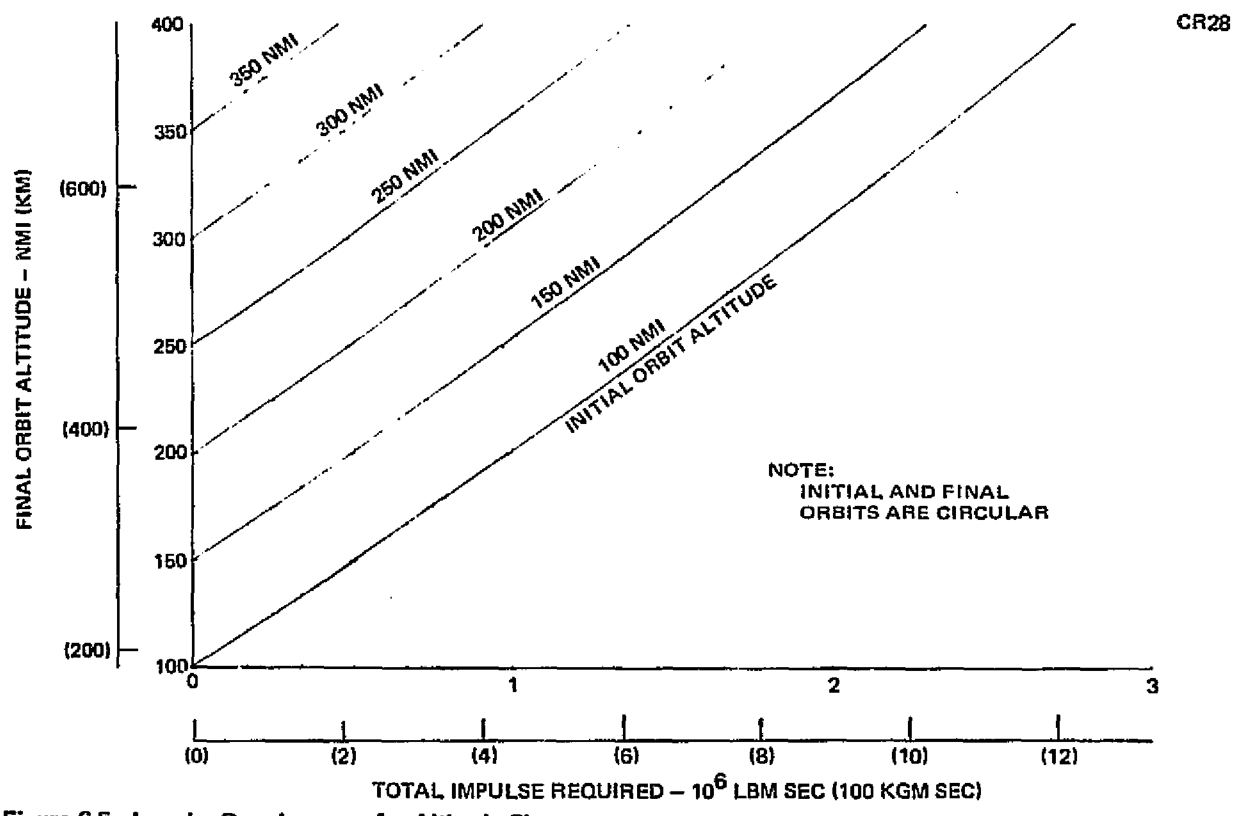

Figure 6-5. Impulse Requirements for Altitude Change

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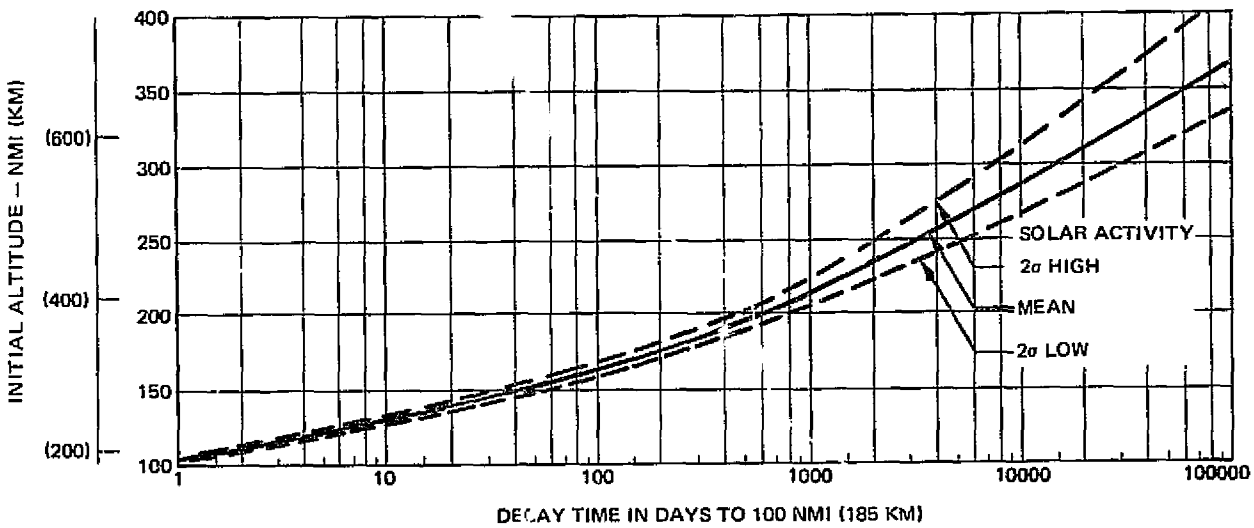

Figure 6-6. Orbital Decay

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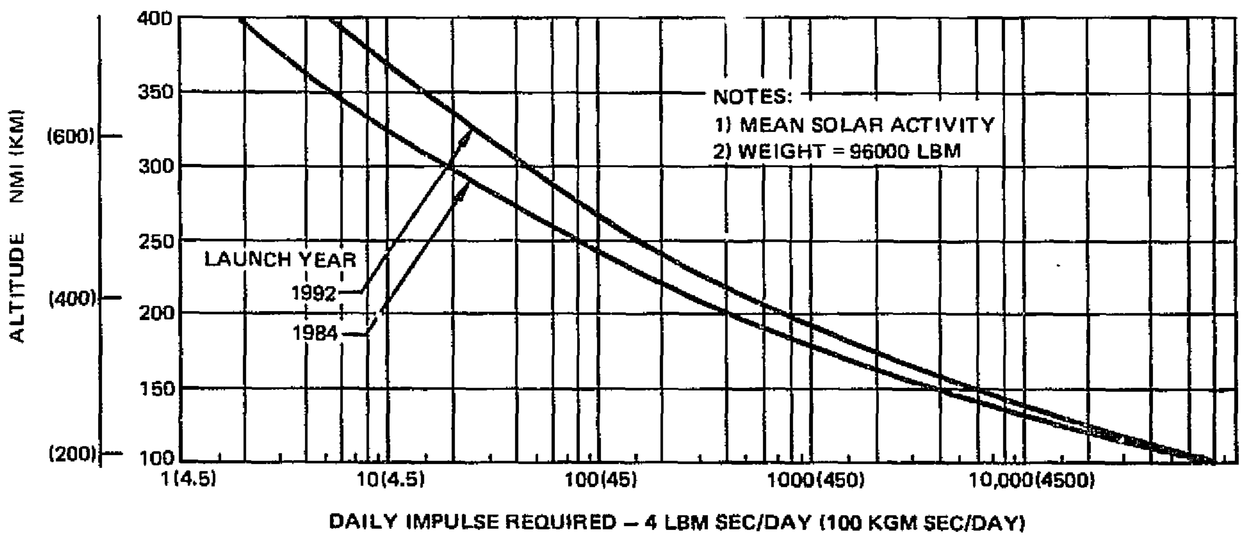

Figure 6-7. Orbit-Keeping Impulse Requirements

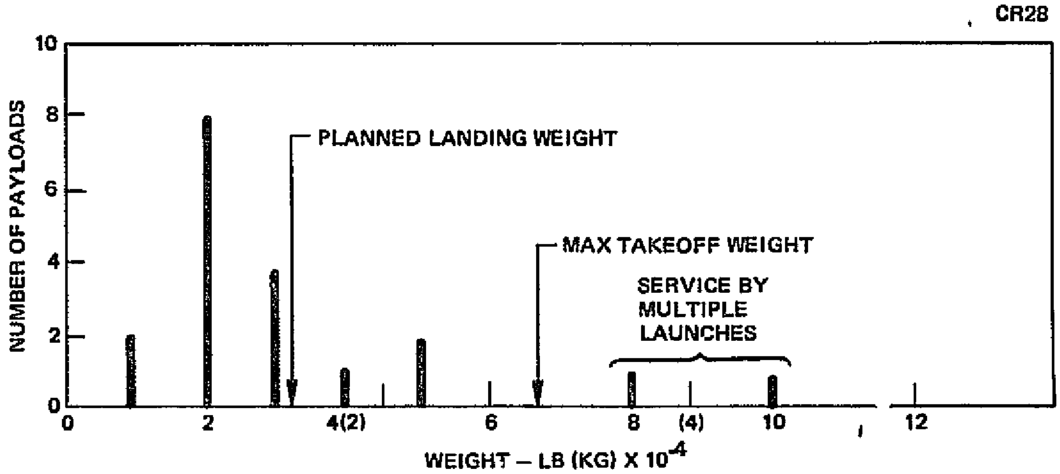

Figure 6-8. Payload Weight

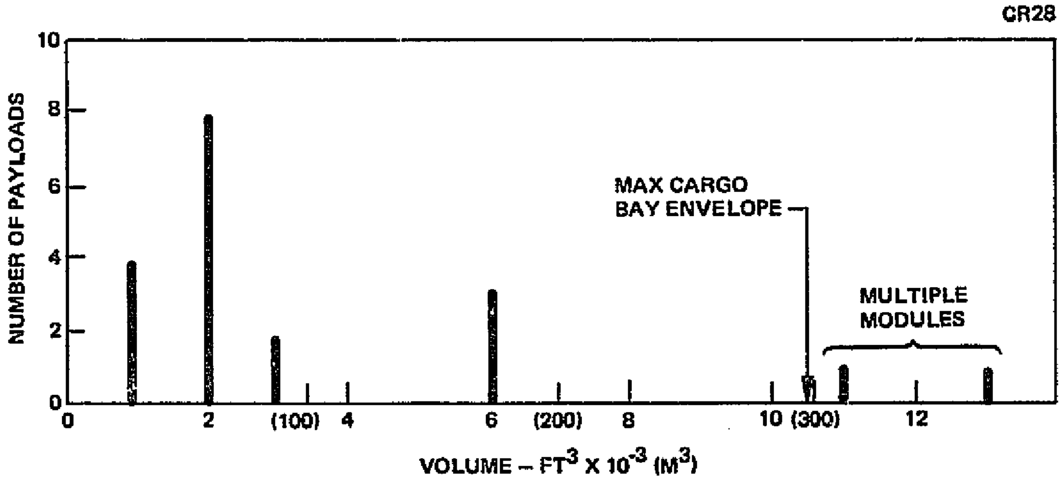

Figure 6-9. Payload Volume

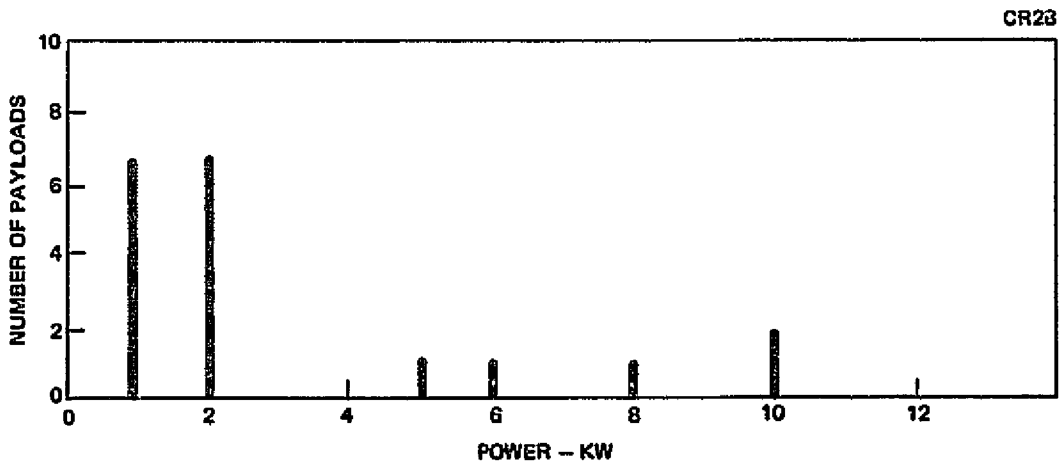

Figure 6-10, Nominal Power

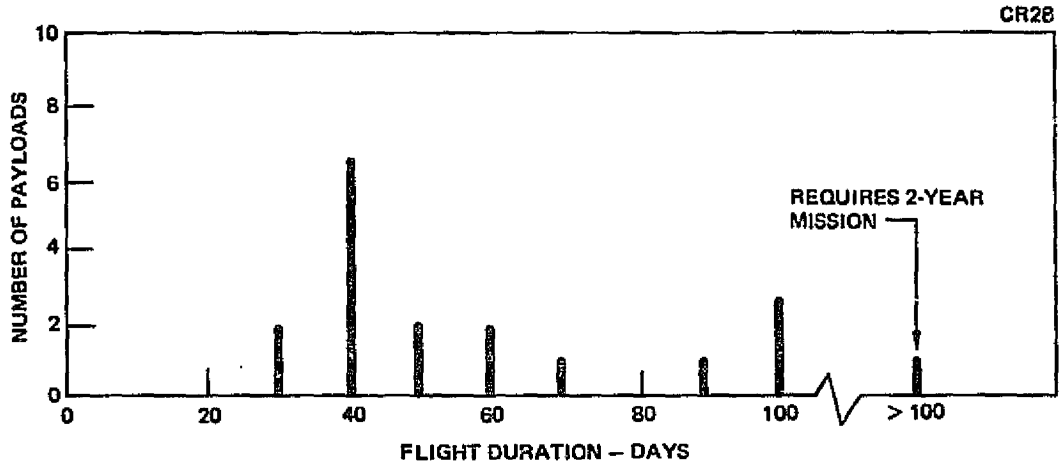

Figure 6-11. Flight Duration

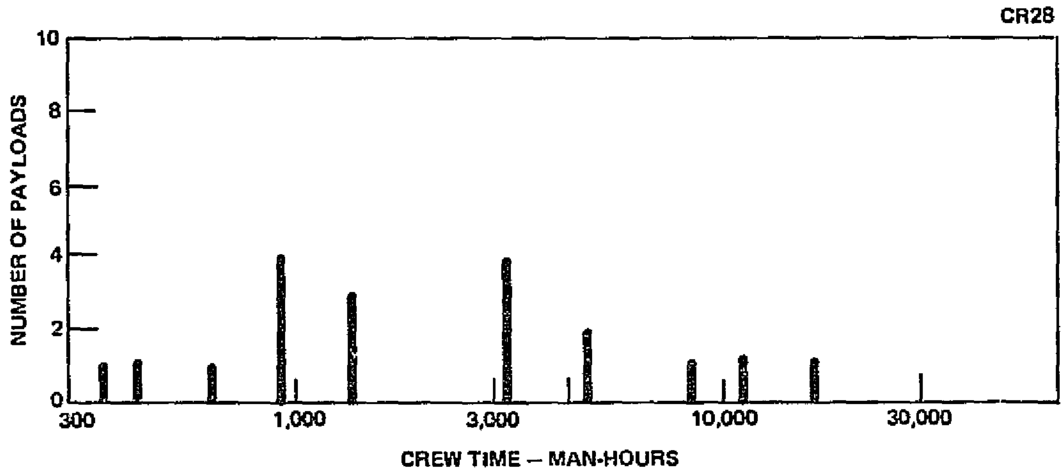

Figure 6-12. Crew Time

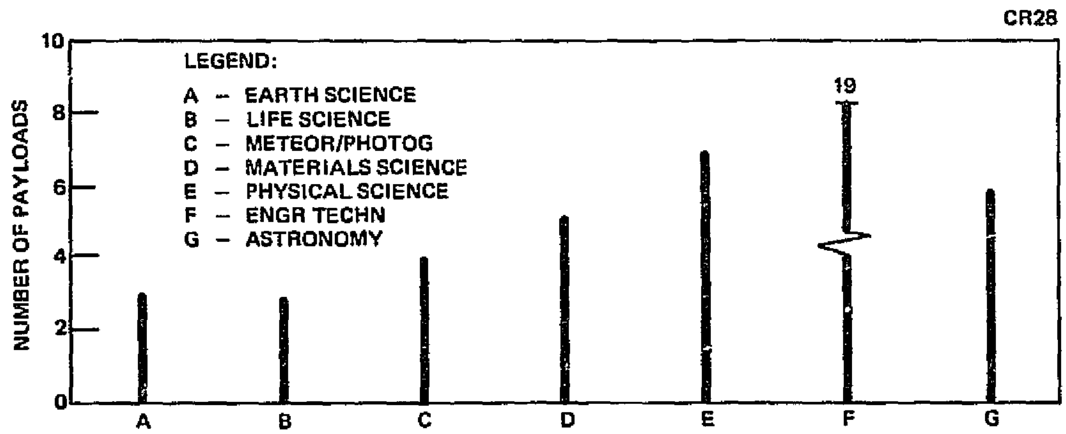

Figure 6-13. Crew Skills

(3) nominal electrical power demand, (4) flight duration, (5) manpower requirements per flight, and (6) crew skills. The largest demand or highest requirement combination is identified in the histograms. As seen in Figure 6-8 only two payloads (C-12 and C-13) exceed the Orbiter maximum cargo takeoff weight and therefore these payloads would require multiple launches in order to become established in orbit. Figure 6-9 depicts an analogous situation for C-12 and C-13 from the standpoint of available Orbiter cargo bay volume. As also seen in Figure 6-8, the weights of 14 out of the 19 payloads do not exceed the planned landing weight of the Orbiter and could be easily returned by a single flight, as the payload program demands. The other five payloads could be retrieved by dividing their equipment into acceptable return packages.

As seen from Figure 6-10 two payloads (C-7 and C-12) require a very significant amount of power. If the power required by these payloads exceeds the nominal design of the facility, they could be accommodated by an auxiliary solar array or alternate power source. Figure 6-11 indicates that each payload flight could be accommodated during a single 90-to-100-day period with the exception of the long-duration 2-year flight period required for C-17.

The three life science combination payloads consistently appear as the most demanding, namely C-12 and C-13 Life Science/Materials Technology Nos. 1 and 2 and C-17 long-duration Life Science Laboratory. This would suggest that the life science payloads, as a class, would best be served by a dedicated MOSC facility not encumbered by the conflicting demands of the other disciplines.

6.3 MOSC DESIGN CRITERIA

From the standpoint of the physical and operational requirements of the payloads examined for extended-duration flights, the following design criteria summarize the carrier requirements. Flight durations of up to 720 days will be required to support very long term life science investigations; most of the other payload combinations can be readily scheduled in a nominal 90-day flight duration. A crew size of four individuals with up to four payload specialties represents the suggested minimum for the baseline design. Con-

tinuous payload power levels of 8 kW with supplementary capability to 10 kW occasioned by the high power space processing payloads will prove adequate. Initially one MOSC at an altitude/inclination of 200 nmi and 28.5° (nominal orbit) and another MOSC at 200 nmi and 90° (polar orbit) can satisfy the requirements of all the payloads provided that an altitude change capability of up to 95 nmi is available when required. For payloads containing remote sensors and optical instruments which require precision pointing the platform vehicle orientation should include an all-attitude 0.1° stabilized pointing accuracy capability. High-precision fine pointing can be achieved by added instrument gimbaling as required. On-board disturbance levels, for critical periods of payload operations, should be limited to a microgravity of 10^{-5} g. Contamination from all sources should be contained for pressurized and unpressurized critical payloads at an environment equivalent to the 100,000 class clean room criterion.

Appendix A
PAYLOAD DATA

A. REQUIREMENTS DATA FOR CANDIDATE MOSC PAYLOADS

This appendix consists of the data describing the 50 payloads considered for further analysis by the MDAC study team. These payloads were (1) the 20 recommended by the NASA study panel, (2) the additional 26 recommended by the study team, and (3) the four space manufacturing payloads recommended by the space processing study activities. The data presented for (1) and (2) above is in the form of tabular summaries; the space manufacturing payloads are described by preliminary SSPDA Level A data sheets.

GENERAL REQUIREMENTS

Sheets AI-1 and -2 contain the general mission requirements for each payload; identification of the codes used on these sheets is as follows, reading the nine columns from left to right:

1. Payload identification number and name per SSPDA, July 1974; an "N" preceding the number identifies the payload as one recommended by the NASA study panel.

2. Identifies the number of SSPDA flights planned during the MOSC era (1984 +).

3-6. These columns identify the type of payload. These types are module (M), pallet (P), module and pallet (M+P) and carry-on (C-O). It should be recognized that this identifies where major hardware items are located. Some payloads (i.e., AS-01-S) require a limited amount of controls in a pressurized area, such as at the orbital payload specialists station.

7. This column identifies the total number of manhours of orbital operations that are desired by the payload during the MOSC era. This is determined by multiplying the total number of flights (Column 2, this sheet) by the manhours for each 7-day flight, as specified in the SSPDA.

GENERAL REQUIREMENTS (SHEET AI-1)

PAYLOAD	FLIGHTS 1984+	PAYLOAD TYPE: MODULE	PALLET	MODULE PALLET	CARRY ON	DESIRED TOTAL MANHOURS IN ORBIT	COMMENTS	SSPDA SHEETS
ASTRONOMY								
N AS-01-S — 1.5m Cryogenically-Cooled IR Telescope	8		P			1403		A B
N AS-03-S — Deep Sky UV Survey Telescope	6		P			873		A B
N AS-04-S — 1m Diffraction Limited UV Optical Telescope	23		P			4002		A B
AS-08-S — Multipurpose 0.5m Telescope	96		P			816		A
AS-10-S — Adv. XUV Telescope	6		P			936		A
AS-13-S — Solar Variation Photometer	192				C-O	1248		A
N AS-15-S — 3.0m Ambient Temperature IR Telescope	9		P			765		A B
AS-19-S — Selected Area Deep Sky Survey Telescope	10		P			720		A
AS-31-S — Combined AS-01, -03, -04, -05-S	15		P			2340		A B
AS-54-S — Combined UV Payload (AS-03-S, 04-S)	5		P			780		A B
AS-01-R — LST Revisit	7		P			672	REQUIREMENTS WILL EVOLVE FROM LST STUDY	A
HIGH ENERGY ASTROPHYSICS								
HE-14-S — Gamma Ray Pallet	5		P			65		A
HE-19-S — Low Energy X-ray Telescope	5		P			390		A
N HE-X-S COSMIC RAY PHYSICS LAB FPE	TBD	M				TBD		BLUE BOOK
HE-11-R — Large High Energy Observatory D Revisit	5		P			120		A
SOLAR PHYSICS								
N SO-01-S — Dedicated Solar Sortie Mission (DSSM)	20		P			5000		A B
ATMOSPHERIC AND SPACE PHYSICS								
N AP-06-S — Atmospheric, Magnetospheric, and Plasmas in Space (AMPS)	27			M+P		8424		A B
EARTH OBSERVATIONS								
N EO-01-S — Zero-G Cloud Physics Laboratory	5	M				177		A B
N EO-05-S — Shuttle Imaging Microwave System (SIMS)	12		P			1028		A B
N EO-06-S — Scanning Spectroradiometer	13		P			209		A B
N EO-07-S — Active Optical Scatterometer	12			M+P		318		A
EARTH AND OCEAN PHYSICS								
N OP-02-S — Multifrequency Radar Land Imagery	11			M+P		303	SAME AS OP-05-S	A B

GENERAL REQUIREMENTS (SHEET AI-2)

PAYLOAD	FLIGHTS 1984+	PAYLOAD TYPE: MODULE	PALLET	MODULE PALLET	CARRY ON	DESIRED TOTAL MANHOURS IN ORBIT	COMMENTS	SSPDA SHEETS
EARTH AND OCEAN PHYSICS								
N OP-03-S — Multifrequency Dual Polarized Microwave Radiometry	7			M+P		193		A B
N OP-04-S — Microwave Scatterometer	6		P			225		A B
N OP-05-S — Multispectral Scanning Imagery	11			M+P		303	SAME AS OP 02-S	A B
N OP-06-S — Combined Laser Experiment	13			M+P		182		A B
SPACE PROCESSING APPLICATIONS								
SP-04-S — SPA No. 4 - General Purpose (Manned) (G+C)	8			M+P		82		A
SP-05-S — SPA No. 5 - Dedicated (Manned) (B+F+L+G+C)	8			M+P		527		A
N SP-14-S — SPA No. 14 - Manned and Automated (B+G+C+FP+LP)	8			M+P		234		A B
SP-15-S — SPA No. 15 - Automated Furnace/Levitation (FP+LP+CP)	8		P			48		A B
SP-16-S — SPA No. 16 - Biological/General (Manned) (B+G+C)	8			M+P		186		A
SP-19-S — SPA No. 19 - Biological and Automated (B+C+FP+LP)	8			M+P		152		A
LIFE SCIENCES								
LS-04-S — Free Flying Teleoperator	8			M+P		72		A B
LS-09-S — Life Sciences Shuttle Laboratory	20	M				21,600		A B
LS-10-S — Life Sciences Carry-on Laboratories	16				C-O	224	SHELF LIFE CONSIDERATIONS	A B
N LS-X-S Life Sciences Long Duration Laboratory	TBD	M				TBD		A
SPACE TECHNOLOGY								
ST-04-S — Wall-less Chemistry + Molecular Beam (Facil. No. 1)	16			M+P		544		A
ST-05-S — Superfluid He + Particle/Drop Positioning (Facil. No. 2)	16	M				544		A
ST-06-S — Fluid Physics + Heat Transfer (Facil. No. 3)	16	M				704		A
ST-08-S — Integrated Real Time Contamination Monitor	TBD		P			TBD	FLIES ON ALL CONTAMINATION SENSITIVE MISSIONS	A B
N ST-21-S — ATL P/L No. 2 (Module + Pallet)	5			M+P		620		A B
ST-22-S — ATL P/L No. 3 (Module + Pallet)	5			M+P		606		A B
ST-23-S — ATL P/L No. 6 (Pallet Only)	6		P			782		A B
COMMUNICATIONS AND NAVIGATION								
N CN-02-S COMM/NAV SHUTTLE SORTIE LAB (4,000 LB)	8			M+P		984		A
CN-04-S — Terrestrial Sources of Noise + Interference	5			M+P		86		A B
CN-06-S — Communication Relay Tests	5			M+P		78		A

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8. This column contains comments regarding general requirements for the payloads.

9. Identifies the types of sheets that are included in the July 1974 SSPDA. The Level A sheets are the two page summaries of the payload characteristics and requirements, while the Level B sheets contain the more detailed information on the payloads. The notation Blue Book[6] refers to a general characteristics writeup describing space station payload requirements not included on SSPDA sheets.

CREW REQUIREMENTS

Sheets AII-1 and -2 contain the assessment of crew requirements and support for each payload. Identification of the codes used on these sheets is as follows, reading the 24 columns from left to right:

1. Payload identification number per SSPDA, July 1974. An "N" preceding the number identifies the payload as one recommended by the NASA study panel.

   The SSPDA identifies the requirements for three general types of skills; technician, experimenter, and scientist.

2, 4, 6. These columns indicate the number of technicians, experimenters, or scientists required to support the payload.

3, 5, 7. Identifies crew skills code for each general type of skill. These are the standardized classification skills described in Section 3 of this report. The skill codes used on these sheets are:

- 2 Biochemist
- 3 Medical Doctor
- 4 Behavioral Scientist
- 5 Astronomer/Astrophysicist
- 7 Electromechanical/Optical Technician
- 8 Photographic Technician
- 9 Geologist
- 10 Meteorologist
- 11 Oceanographer

[6]Reference Earth Orbital Research and Applications Investigation, NHB 7150.1, NASA, January 15, 1971.

CREW REQUIREMENTS (SHEET AII-1)

PAYLOAD	TECH	CODE	EXPERIMENTER	CODE	SSPDA DATA: SCIENTIST	CODE	MANHOURS PER DAY	MANHOURS PER 7 DAYS	GROUND OPERATIONS	EVA	EVA DURATION	30 DAY COMPAT	MISSION DESIRE	7 DAYS: CREW SIZE	MANHOURS PER DAY	TOTAL MANHOURS	30 DAYS: MANHOURS PER DAY	TOTAL MANHOURS	60 DAYS: MANHOURS PER DAY	TOTAL MANHOURS	90 DAYS: MANHOURS PER DAY	TOTAL MANHOURS
ASTRONOMY																						
N AS-01-S —	1	7	1-GRD	5	GND	—	24	175.4	Y	C	—		1,3,4	2	16	104	16	400	16	800	16	1200
N AS-03-S —	1	7	1-GRD	5	GND	—	24	145.4	S	C	—	4	3	2	16	104	16	400	16	800	16	1200
N AS-04-S —	1	7	1-GRD	5	GND	—	24	174	Y	C	—		1,3,4	2	16	104	16	400	16	800	16	1200
AS-08-S —	1	7	GND		GND		1	8.5	Y	C	—	4		1	1	9	1	28	1	53	1	81
AS-10-S —	1	7	1	5	GND		24	156	S	C			1,4	2	16	104	16	400	16	800	16	1200
AS-13-S —	1	7					1	6.5	—	C	—	4		1	1	6	1	29	1	54	1	78
N AS-15-S —	1	7			GND		12	85	S	C	—		1,3,4	1	8	52	8	200	8	400	8	600
AS-19-S —			1	5			12	72	S	C	—		1,4	1	8	52	8	200	8	400	8	600
AS-31-S —	1	7	1	5	GND		24	156	S	C	—		1,4	2	16	104	16	400	16	800	16	1200
AS-54-S —	1	7	1	5	GND		24	156	S	C	—	4		2	16	104	16	400	16	800	16	1200
AS-01-R —	1	7	1	5			24	96	S	C	—	4		2	16	TBD	16	TBD	16	TBD	16	TBD
HIGH ENERGY ASTROPHYSICS																						
HE-11-S —			1	5	GND		2	13	YES	C	—	-	1,4	1	2	13	2	50	2	86	2	146
HE-19-S —			1	5	GND		12	78	S	C		X	4	1	8	52	8	200	8	400	8	600
N HE-X-S —	1	7	1	5	GND	—	—	—	S	C			2,3,4	2	2	24	2	56	2	116	2	162
HE-11-R —			1	5	GND		2	24	S	3		4		2	16	TBD	16	TBD	16	TBD	16	TBD
SOLAR PHYSICS																						
N SO-01-S —	7	7	2	5	1	5	50	250	—	C			1,3,4	4	32	208	32	800	32	1600	32	2400
ATMOSPHERIC AND SPACE PHYSICS																						
N AP-06-S —	2	7	1	5	1	5	24/48	312	—	C			3,4	4	32	208	32	800	32	1600	32	2400
EARTH OBSERVATIONS																						
N EO-01-S —	1	7	1	10	GND	--	8.2	35.4	S	—	—	4	3	1/2	8	36	8	152	8	304	8	468
N EO-05-S —	1	7	1	9/11/12/13	GND	—	15.12	85.68	S	C	—	4	3	2	16	104	16	400	16	800	16	1200
N EO-06-S —			1	9/11/12/13	GND		3.22	16.1	S	C	—	4	3	1	3	16	3	67	3	134	3	208
N EO-07-S —			1	9/11/12/13	GND	—	6.5	26.5	S	C	—	4	3	1	6	27	6	115	6	230	6	350
EARTH AND OCEAN PHYSICS																						
N OP-12-S —	1	8	1	9/11	1	13/12	5.5	27.5		C		4	3	1/2	6	28	6	118	6	236	6	364

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CREW REQUIREMENTS (SHEET AII-2)

PAYLOAD	TECH	CODE	EXPERI-MENTER	CODE	SSPDA DATA: SCIENTIST	CODE	MANHOURS PER DAY	MANHOURS PER 7 DAYS	GROUND OPERATIONS	EVA	EVA DURATION	30 DAY COMPAT	MISSION DESIRE	7 DAYS: CREW SIZE	MANHOURS PER DAY	TOTAL MANHOURS	30 DAYS: MANHOURS PER DAY	TOTAL MANHOURS	60 DAYS: MANHOURS PER DAY	TOTAL MANHOURS	90 DAYS: MANHOURS PER DAY	TOTAL MANHOURS
EARTH AND OCEAN PHYS																						
N OP-03-S —	1	7	1	10/11/13	—		8.3	27.5		C		4	3	1/2	8	28	8	120	8	240	8	370
N OP-04-S —			2	11	—		7.5	37.5		C		4	3	1/2	8	33	8	120	8	240	8	370
N OP-05-S —	1	7	1	9/11	—		5.5	27.5		C		4	3	1/2	6	28	6	118	6	236	6	364
N OP-06-S —	1	8	1	10/11	GND		2.8	14	5	C		4	3	1/2	3	14	3	60	3	120	3	182
SPACE PROCESSING																						
SP-01-S —			1	17			1.0 TO 1.8	10.3		—		4		1	2	10	2	42	2	84	2	130
SP-05-S —	1	7	1	17			4.5 TO 11.4	65.9		—		4		1/2	8	48	8	200	8	400	8	624
N SP-14-S —	1	2	1	17			2.5 TO 5	29.3		—		4	3	1/2	4	28	4	116	4	232	4	364
SP-15-S —	1	7	1	17			0.4 TO 1	6		—		4		1/2	1	6	1	25	1	50	1	80
SP-16-S —			1	17			2.3 TO 4	23.3		—		4		1	3	23	3	80	3	160	3	302
SP-19-S —	1	7	1	17			1.5 TO 3.2	19		—		4		1/2	3	20	3	75	3	150	3	300
LIFE SCIENCES																						
LS-04-S —	1	7	1	4			4.5	9	5	C	—	4	3	1	5	9	5	38	5	76	5	120
LS-09-S —	1	7	1	14/4	1	3	36	30 DAYS 1080					2,3,4	3	24	156	24	672	24	1344	24	1872
LS-10-S —			1	3/21			2	14				4	3	1	2	14	2	58	2	116	2	182
N LS-X-S	1	7	3	4/21	2	3/4	10	180 DAYS 9600					2,3,4	4	32	192	32	8960	32	17,920	32	25,000
SPACE TECHNOLOGY																						
ST-04-S —			1	18/19			9	34		—		4		1	8	34	8	145	8	290	8	440
ST-05-S —			1	19			9	34		—		4		1	8	34	8	145	8	290	8	440
ST-06-S —			1	19			8	44		—		4		1	8	44	8	182	8	290	8	572
ST-09-S —			1	14						—		4		0								
N ST-21-S —	2	7/8	1	19			24	124		C		4	3	2	16	100	16	400	16	800	16	1200
ST-22-S —			2	19/21			18.6	121.1		C		4		2	16	100	16	400	16	800	16	1200
ST-23-S —	1	7	2	17/19			29.6	130.4		C		4		2	16	100	16	400	16	800	16	1200
COMMUNICATIONS AND NAVIGATION																						
N CN-02-S —	1	7	1	14			24.6	123		C		4	3	2	16	102	16	400	16	800	16	1200
CN-04-S —			1	14			3.45	17.25		YES	UNKNOWN	4		1	4	18	4	72	4	144	4	234
CN-06-S —	1	7	1	14			3	15.5		C		4		1	3	16	3	66	3	136	3	208

12 Agronomist
13 Geographer
14 Electronics Engineer
17 Metallurgist
18 Chemist
19 Physicist
21 Biochemist

8,9. Indicates, in manhours, the level of crew support required on a daily basis and extended over a 7-day flight.

10. Indicates ground control capabilities. A "Y" or "yes" indicates that primary control of the payload operations remains on the ground. An "S" indicates that control is shared between orbital and ground operations. A "--" indicates no ground control.

11. The requirements for extravehicular activities (EVA) are shown by entries indicating the number of crew members required for EVA. A "C" indicates that EVA is on a contingency only basis.

12. This column indicates the duration of required EVA in hours.

13, 14. These two columns indicate the compatibility with or the desirability of a 30-day duration flight compared to a 7-day duration flight considering the crew/payload interface. An "X" indicates compatibility or desirability. The code for the numbers in these columns is as follows:
1 Desired by principal investigator
2 Required by principal investigator
3 NASA panel recommendation
4 MDAC recommendation

15. The crew size for a 7-day flight is shown. A "1/2" in this column indicates that the payload requires only part-time support.

16, 17. These columns indicate the number of manhours required per day and for a 7-day flight.

18-23. These columns indicate the number of manhours per day and entire flight for flight lengths of 30, 60, and 90 days.

24. Intentionally blank.

ORBITAL REQUIREMENTS

Sheets AIII-1 through -4 compile the specific orbital requirements for each payload in both English units and the International System of units (SI). Identification of the codes used on these sheets is as follows, reading the 24 columns from left to right:

1. Payload identification number per SSPDA, July 1974. An "N" preceding the number identifies the payload as one recommended by the NASA study panel.

2-10. These columns indicate the apogee, perigee, and inclination for each payload. The desired value is for optimum operation; the minimum and maximum values are those which can provide acceptable results.

11. This column identifies the most acceptable launch sites, due to inclination requirements. ETR is the Kennedy Space Center and WTR is the Vandenberg Launch Site.

12. Intentionally blank.

13-16. These columns identify specific viewing orientation requirements and any special constraints that should be satisfied for payload operation.

17. Pointing accuracy required of the gimbal mount/platform is indicated in this column.

18. This column indicates the pointing stability required of the gimbal mount/platform.

19. The maximum duration in hours per operation that the pointing system must maintain the required values is identified in this column.

C. 2

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ORBITAL REQUIREMENTS (IN ENGLISH) (SHEET AIII-1)

PAYLOAD	APOGEE (N.MI) DESIRED	APOGEE MIN	APOGEE MAX	PERIGEE (N.MI) DESIRED	PERIGEE MIN	PERIGEE MAX	INCLINATION (DEG) DESIRED	INCLINATION MIN	INCLINATION MAX	LAUNCH SITE	VIEWING ORIENTATION	VIEWING CONSTRAINTS	POINTING ACCURACY SEC	POINTING STABILITY SEC	DURATION HR/ORB	STABILITY RATE SEC/SEC	FIELD OF VIEW DEG	IS SPECIAL MOUNT REQ'D	ACCELERATION g
ASTRONOMY																			
N AS-01-S –	216	162	340	216	162	340	28.5	0	104	ETR/WTR	STELLAR	>15° FROM EARTH >45° FROM SUN	10	1	1.55	0.[illegible]	100	YES	1E-03
N AS-03-S –	162	135	216	162	135	216	28.5	0	57	ETR	ECLIPTIC AWAY FROM SUN	>15° FROM EARTH >9 FROM SUN	5	1	0.25	0.1	100	YES	1E-03
N AS-01-S –	162	135	216	162	135	216	ANY	28.5	104	ETR/WTR	STELLAR	>15° FROM EARTH >45° FROM SUN	1	1	1.5	0.1	100	NO	1E-03
AS-05-S –	250	175	400	250	175	400	28	22	70	ETR/WTR	STELLAR	>15° FROM EARTH >45° FROM SUN	2	2	1.55	NONE	100	YES	1E-03
AS-10-S –	248	240	258	248	240	258	ANY	0	104	ETR/WTR	STELLAR	>15° FROM EARTH >45° FROM SUN	1	1	1.55	0.1	100	YES	1E-04
AS-13-S –	ANY	100	400	ANY	100	400	ANY	ANY	ANY	ETR/WTR	SOLAR	>20° FROM EARTH	1800	1800	0.1	NONE	100	YES	1.0
N AS-15-S –	216	100	270	216	100	270	ANY	28	104	ETR/WTR	STELLAR	>15° FROM EARTH >90° FROM SUN	5	1	0.88	0.2	100	YES	1E-03
AS-19-S –	216	135	432	216	135	432	28	28	55	ETR	STELLAR	>20° FROM EARTH >45° FROM SUN	5	0.3	0.83	2	100	YES	1E-03
AS-31-S –	162	135	216	162	135	216	28.5	0	104	ETR/WTR	STELLAR	>15° FROM EARTH >90° FROM SUN	1	1	1.5	0.1	100	YES	1E-03
AS-54-S –	162	135	216	162	135	216	28.5	28.5	57	ETR	STELLAR	>15° FROM EARTH >90° FROM SUN	1	1	1.5	0.1	100	YES	1E-03
AS-01-R –	281	270	329	281	270	329	28.5	28	30	ETR	BAY TOWARD TDRS	TDRS CONTACT FROM LST	1800	1800	4	30	NONE	NO	1E-03
HIGH ENERGY ASTROPHYSICS																			
HE-11-S –	120	108	128	120	108	128	28.5	28	30	ETR	SELECTED STELLAR OBJECTS	>15° FROM EARTH	360	360	1.5	NONE	40	NO	1E-05
HE-19-S –	120	109	132	120	109	132	[illegible]	15	28.5	ETR	STELLAR	>15° FROM EARTH	360	1	1.5	1	60	NO	1E-03
N HE-X-S –	200	200	270	200	200	270	28	28	55	ETR	STELLAR	AWAY FROM EARTH	NONE	NONE	–	NONE	NONE	NO	NONE
HE-11-R –	250	240	260	250	240	260	15	0	28.5	ETR	BAY TOWARD TDRS	TDRS CONTACT WITH PAYLOAD	1800	1800	4	1	NONE	NO	1E-03
SOLAR PHYSICS																			
N SO-01-S –	189	189	216	189	189	216	30	0	32	ETR	SOLAR INERTIAL	VIEW SUN	1	0.5	0.83	0.001	10	YES	1E-03
ATMOSPHERIC AND SPACE PHYSICS																			
N AP-06-S –	235	216	270	235	216	270	28.5	28.5	28.5	ETR	EARTH AND LOCAL MAGNETIC FIELDS	NONE	1800	360	0.5	360	±77	NO	1E-03
EARTH OBSERVATIONS																			
N EO-01-S –	ANY	100	ANY	ANY	100	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-05
N EO-05-S –	235	210	260	235	210	260	70	30	90	ETR/WTR	EARTH	NONE	1800	900	0.33	1080	45	NO	1E-01
N EO-06-S –	183	100	250	183	100	250	65	30	65	ETR/WTR	EARTH	NONE	3600	1800	0.25	72	48	NO	1E-01
N EO-07-S –	100	ANY	200	100	ANY	200	90	ANY	110	ETR/WTR	EARTH	NONE	[illegible]	1800	0.5	360	±77	NO	0.01
EARTH AND OCEAN PHYSICS																			
N OP-02-S –	108	100	135	108	100	135	57	28	57	ETR/WTR	EARTH	NONE	1800	450	0.75	1.50	±77	NO	1E-01

ORBITAL REQUIREMENTS (INSI) (SHEET AIII-2)

PAYLOAD	APOGEE (KM)			PERIGEE (KM)			INCLINATION (DEG)			LAUNCH SITE	VIEWING		POINTING					SPECIAL MOUNT REQ'D	ACCELERATION g
	DESIRED	MIN	MAX	DESIRED	MIN	MAX	DESIRED	MIN	MAX		ORIENTATION	CONSTRAINTS	ACCURACY RAD	STABILITY RAD	DURATION HR/OPN	STABILITY RATE RAD/SEC	FIELD OF VIEW RAD		
ASTRONOMY																			
N AS-01-S —	400	300	630	400	300	630	28.5	0	104	ETR/WTR	STELLAR	>15° FROM EARTH >45° FROM SUN	4.8E-05	4.8E-06	1.55	1.7E-07	1.75	YES	1E-03
N AS-03-S —	300	250	400	300	250	400	28.5	0	57	ETR	CELESTIAL-AWAY FROM SUN	>15° FROM EARTH >90° FROM SUN	2.4E-05	4.8E-06	0.25	4.8E-07	1.75	YES	1E-03
N AS-04-S —	300	250	400	300	250	400	ANY	28.5	104	ETR/WTR	STELLAR	>15° FROM EARTH >45° FROM SUN	4.8E-06	4.8E-06	1.5	4.8E-07	1.75	NO	1E-03
AS-08-S —	463	324	740	463	324	740	28	28	90	ETR/WTR	STELLAR	>15° FROM EARTH >45° FROM SUN	9.7E-06	9.7E-06	1.55	NONE	1.75	YES	1E-03
AS-10-S —	460	445	480	460	445	480	ANY	0	104	ETR/WTR	STELLAR	>15° FROM EARTH >45° FROM SUN	4.8E-06	4.8E-06	1.55	4.8E-07	1.75	YES	1E-04
AS-13-S —	ANY	185	740	ANY	185	740	ANY	ANY	ANY	ETR/WTR	SOLAR	>28 FROM EARTH	8.7E-03	8.7E-03	0.1	NONE	1.75	YES	1.0
N AS-15-S —	400	185	500	400	185	500	ANY	28	104	ETR/WTR	STELLAR	>30° FROM EARTH >90° FROM SUN	2.4E-05	4.8E-06	0.88	9.7E-07	1.75	YES	1E-03
AS-19-S —	400	250	800	400	250	800	28	28	55	ETR	STELLAR	>20° FROM EARTH >45° FROM SUN	2.4E-05	1.5E-06	0.83	9.7E-06	1.75	YES	1E-03
AS-31-S —	300	250	400	300	250	400	28.5	0	104	ETR/WTR	STELLAR	>15° FROM EARTH >90° FROM SUN	4.8E-06	4.8E-06	1.5	4.8E-07	1.75	YES	1E-03
AS-54-S —	300	250	400	300	250	400	28.5	28.5	57	ETR	STELLAR	>15° FROM EARTH >90° FROM SUN	4.8E-06	4.8E-06	1.5	4.8E-07	1.75	YES	1E-03
AS-01-R —	520	500	610	520	500	610	28.5	28	30	ETR	BAY TOWARD TDRS	TDRS CONTACT FROM LST	8.7E-03	8.7E-03	4	1.5E-04	NONE	NO	1E-03
HIGH ENERGY ASTROPHYSICS																			
HE-14-S —	223	200	237	223	200	237	28.5	28	30	ETR	SELECTED STELLAR OBJECTS	>15° FROM EARTH	1.7E-03	1.7E-03	1.5	NONE	0.69	NO	1E-05
HE-19-S —	223	201	245	223	201	245	22	15	28.5	ETR	STELLAR	>15° FROM EARTH	1.7E-03	4.8E-06	1.5	4.8E-06	1.05	NO	1E-03
N HE-X-S —	370	370	500	370	370	500	28	28	55	ETR	STELLAR	AWAY FROM EARTH	NONE	NONE	—	NONE	NONE	NO	NONE
HE-11-R —	463	445	482	463	445	482	15	0	28.5	ETR	BAY TOWARD TDRS	TDRS CONTACT WITH PAYLOAD	8.7E-03	8.7E-03	4	4.8E-06	NONE	NO	1E-03
SOLAR PHYSICS																			
N SO-01-S —	350	350	400	350	350	400	30	0	32	ETR	SOLAR INERTIAL	VIEW SUN	4.8E-06	2.4E-06	0.83	5.3E-09	0.17	YES	1E-03
ATMOSPHERIC AND SPACE PHYSICS																			
N AP-06-S —	435	400	500	435	400	500	28.5	28.5	28.5	ETR	EARTH AND LOCAL MAGNETIC FIELDS	NONE	8.7E-03	1.7E-03	0.5	1.7E-03	±1.34	NO	1E-03
EARTH OBSERVATIONS																			
N EO-01-S —	ANY	185	ANY	ANY	185	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-05
N EO-05-S —	435	389	481	435	389	481	70	30	90	ETR/WTR	EARTH	NONE	8.7E-03	4.4E-03	0.33	5.2E-03	0.79	NO	1E-01
N EO-06-S —	339	185	463	339	185	463	65	30	65	ETR/WTR	EARTH	NONE	1.7E-02	8.7E-03	0.25	3.5E-04	0.84	NO	1E-01
N EO-07-S —	185	ANY	370	185	ANY	370	90	ANY	110	ETR/WTR	EARTH	NONE	8.7E-03	8.7E-03	0.5	1.7E-03	±1.34	NO	0.01
EARTH AND OCEAN PHYSICS																			
N OP-02-S —	200	185	250	200	185	250	57	28	57	ETR/WTR	EARTH	NONE	8.7E-03	4.4E-03	0.75	5.2E-03	±1.34	NO	1E-01

ORBITAL REQUIREMENTS (IN ENGLISH) (SHEET AIII-3)

PAYLOAD	APOGEE (N. MI)			PERIGEE (N. MI)			INCLINATION (DEG)			LAUNCH SITE	VIEWING		POINTING					SPECIAL MOUNTING REQ'D	ACCEL-ERATION g
	DESIRED	MIN	MAX	DESIRED	MIN	MAX	DESIRED	MIN	MAX	SITE	ORIENTATION	CONSTRAINTS	ACCURACY SEC	STABILITY SEC	DURATION HR/ORN	STABILITY RATE SEC/SEC	FIELD OF VIEW RAD		
EARTH AND OCEAN PHYS																			
N OP-03-S —	108	100	135	108	100	135	57	28	57	ETR/WTR	EARTH	NONE	1800	360	1.0	1080	±77	NO	1.0
N OP-04-S —	108	100	135	108	100	135	90	28	110	ETR/WTR	EARTH	NONE	1800	900	0.1	1080	±77	NO	1E-01
N OP-05-S —	108	100	135	108	100	135	90	28	110	ETR/WTR	EARTH	NONE	360	900	0.75	1080	±77	NO	1E-01
N OP-06-S —	108	100	135	108	100	135	57	28	57	ETR/WTR	EARTH	NONE	1800	900	0.75	1080	±77	NO	1.0
SPACE PROCESSING																			
SP-01-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-05-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
N SP-14-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-15-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-16-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-19-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
LIFE SCIENCES																			
LS-04-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	NONE
LS-09-S —	200	ANY	ANY	200	ANY	ANY	28.5	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-03
LS-10-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-05
N LS-X-S	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-03
SPACE TECHNOLOGY																			
ST-04-S —	270	150	351	270	150	351	55	23	90	ETR/WTR	ANY	NONE	1800	360	0.5	360	NONE	NO	1E-04
ST-05-S —	100	100	ANY	100	100	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
ST-06-S —	100	100	ANY	100	100	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
ST-08-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	NONE
N ST-21-S —	100	100	300	100	100	300	TBD	TBD	TBD	ETR/WTR	EARTH, STELLAR	ANTI-SOLAR, 15° CONE	1800	1800	0.5	360	170	NO	1E-02
ST-22-S —	100	100	300	100	100	300	TBD	TBD	TBD	ETR/WTR	EARTH	ANTI-SOLAR, 15° CONE	1800	1800	0.5	360	20	NO	1E-02
ST-23-S —	200	100	300	200	100	300	60	TBD	90	ETR/WTR	EARTH, STELLAR	ANTI-SOLAR 15° CONE	1800	720	0.75	360	170	NO	1E-02
COMMUNICATIONS AND NAVIGATION																			
N CN-02-S —	200	100	470	200	100	470	60	0	90	ETR/WTR	EARTH, STELLAR	CONUS, SPECIAL GRD. STA	1800	1800	4	180	180	NO	3.5
CN-04-S —	200	150	250	200	150	250	55	45	90	ETR/WTR	EARTH	CONUS	1800	1800	0.1	360	360	NO	1
CN-06-S —	200	150	250	200	150	250	55	0	90	ETR/WTR	TDRS VIEWING	NONE	3600	1800	0.25	180	180	NO	1

ORBITAL REQUIREMENTS (INSI) (SHEET AIII-4)

PAYLOAD	APOGEE (Km) DESIRED	MIN	MAX	PERIGEE (Km) DESIRED	MAX	MIN	INCLINATION (DEG) DESIRED	MIN	MAX	LAUNCH SITE	VIEWING ORIENTATION	CONSTRAINTS	POINTING ACCURACY RAD	STABILITY RAD	DURATION HR/OPN	STABILITY RATE RAD/SEC	FIELD OF VIEW RAD	IS SPECIAL MOUNT REQ'D	ACCELERATION g
EARTH AND OCEAN PHYS																			
N OP-03-S —	200	185	250	200	185	250	57	28	57	ETR/WTR	EARTH	NONE	8.7E-03	1.7E-03	1.0	5.2E-03	±1.34	NO	1.0
N OP-04-S —	200	185	250	200	185	250	70	28	110	ETR/WTR	EARTH	NONE	8.7E-03	4.4E-03	0.1	5.2E-03	±1.34	NO	1E-01
N OP-05-S —	200	185	250	200	185	250	70	[illegible]	110	ETR/WTR	EARTH	NONE	1.7E-03	4.4E-03	0.75	5.2E-03	±1.34	NO	1E-01
N OP-06-S —	200	185	250	200	185	250	[illegible]	28	57	ETR/WTR	EARTH	NONE	8.7E-03	4.4E-03	0.75	5.2E-03	±1.34	NO	1.0
SPACE PROCESSING																			
SP-04-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-05-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
N SP-14-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-15-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-16-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-19-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
LIFE SCIENCES																			
LS-04-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	NONE
LS-09-S —	370	ANY	ANY	370	ANY	ANY	28.5	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-03
LS-10-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-05
N LS-X-S	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-03
SPACE TECHNOLOGY																			
ST-04-S —	500	278	650	500	278	650	55	23	90	ETR/WTR	ANY	NONE	8.7E-03	1.7E-03	0.5	1.7E-03	NONE	NO	1E-04
ST-05-S —	185	185	ANY	185	185	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
ST-06-S —	185	185	ANY	185	185	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
ST-08-S —	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	NONE
N ST-21-S -	185	185	555	185	185	555	TBD	TBD	TBD	ETR/WTR	EARTH, STELLAR	ANTI-SOLAR, 15° CONE	8.7E-03	8.7E-03	0.5	1.7E-03	2.97	NO	1E-02
ST-22-S —	185	185	555	185	185	555	TBD	TBD	TBD	ETR/WTR	EARTH	ANTI-SOLAR 15° CONE	8.7E-03	8.7E-03	0.5	1.7E-03	0.35	NO	1E-02
ST-23-S —	370	185	555	370	185	555	60	TBD	90	ETR/WTR	EARTH, STELLAR	ANTI-SOLAR, 15° CONE	8.7E-03	3.5E-03	0.75	1.7E-03	2.97	NO	1E-02
COMMUNICATIONS AND NAVIGATION																			
N CN-02-S —	370	185	870	350	185	370	60	0	90	ETR/WTR	EARTH, STELLAR	CONUS, SPECIAL GEO STA	8.7E-03	8.7E-03	4	1.7E-04	2.44	NO	3.5
CN-04-S —	370	278	463	370	278	463	55	45	90	ETR/WTR	EARTH	CONUS	8.7E-03	8.7E-03	0.1	1.7E-03	6.28	NO	1
CN-06-S —	370	278	463	370	278	463	55	0	90	ETR/WTR	TDRS VIEWING	NONE	1.7E-02	8.7E-03	0.25	1.7E-04	3.14	NO	1

20. This column identifies the maximum allowable angular velocity or jitter rate of the payload line of sight.

21. This column indicates the field of view of the payload equipment (such as antenna, telescope or detector).

22. A "yes" in this column indicates that a special gimbal mount or pointing platform is required in order to obtain satisfactory data. A "no" indicates that the basic Spacelab/Orbiter pointing accuracies are acceptable.

23. This column identifies the translational acceleration limits of each payload, while operating. The use of "E" refers to exponent (i. e., IE-03 is 1×10^{-3}).

24. Intentionally blank.

WEIGHT AND ENERGY REQUIREMENTS

Sheets AIV-1 through -4 compile the weight and energy characteristics for each payload, in English units and in the International System of units (SI). Identification of the codes used on these sheets is as follows, reading the 24 columns from left to right:

1. Payload identification number per SSPDA, July 1974. An "N" preceding the number identifies the payload as one recommended by the NASA study panel.

2. This is the launch weight for the payload for a 7-day flight. Includes equipment and consumables.

3. This is the payload weight after a 7-day flight.

4. This column indicates the weight of consumables for a 7-day flight.

5-7. These columns indicate the weight of consumables for 30-, 60-, and 90-day flights. These values are extrapolated from the 7-day consumable values. In these calculations it was assumed that payload operation

WEIGHT AND ENERGY (IN ENGLISH) (SHEET AIV-1)

PAYLOAD	7 DAYS LAUNCH WT (LBS)	7 DAYS DOWN WT (LBS)	CONSUMABLES (LBS) 7	CONSUMABLES (LBS) 30	CONSUMABLES (LBS) 60	CONSUMABLES (LBS) 90	SPARES (LBS) 30	SPARES (LBS) 60	SPARES (LBS) 90	TOTAL WEIGHT (LBS) 30	TOTAL WEIGHT (LBS) 60	TOTAL WEIGHT (LBS) 90	SPARES CODE	POWER (W) AVERAGE	POWER (W) PEAK	ENERGY (KWHR) 7	ENERGY (KWHR) 30	ENERGY (KWHR) 60	ENERGY (KWHR) 90
ASTRONOMY																			
N AS-01-S —	7251	6915	1234	6912	14,318	21,723	72.6	145.2	270.4	13002	20,480	28,030	A	944	1162	148	829	1717	2605
N AS-03-S —	8303	8303	—	—	—	—	83.6	165	332	8387	8468	8635	A	992	1377	172	963	1995	3027
N AS-04-S —	4039	3703	576	3227	6686	10,144	39.6	81.4	160.6	6730	10,230	13,768	A	400	500	58	325	673	1021
AS-08-S —	1219	1109	110	616	1276	1936	24.2	61.6	121	1749	2447	3166	B	100	150	14.4	81	167	253
AS-10-S —	937	893	44	246	510	774	8.8	19.8	37.4	1148	1423	1704	A	400	452	62	347	719	1091
AS-13-S —	44	44	—	—	—	—	4.4	8.8	17.6	48.4	52.8	61.6	D	20	20	0.25	1.6	3.2	4.9
N AS-15-S —	11,717	11,585	530	2970	6151	9332	235.4	585	1173	14,392	17,923	21,692	B	944	1162	148	829	1717	2605
AS-19-S —	2200	2090	110	616	1276	1936	22	44	88	2728	3410	4114	A	400	500	58	325	673	1021
AS-31-S —	17,620	15,107	2512	14,069	29,143	44,218	352	880	1762	29,529	45,131	61,088	B	2429	3367	371	2078	4304	6530
AS-54-S —	15,437	13,435	2121	11,876	24,600	37,325	308	772	1544	25,509	38,688	52,185	B	1392	1877	201	1126	2332	3538
AS-01-R —	9680	9251	440	2464	5104	7744	96.8	193.6	387	11,801	14,538	17,371	A	1200	1400	115	644	1334	2024
HIGH ENERGY ASTROPHYSICS																			
HE-14-S —	10,311	10,223	88	493	1021	1549	103.4	206.8	411	10,819	11,451	12,183	A	360	360	56	314	650	986
HE-19-S —	3991	3881	110	616	1276	1936	39.6	79.2	160.6	4537	5236	5978	A	356	450	55.5	311	644	977
N HE-X-S —	34,320	34,320	138.6	777	1608	2440	3089	7550	13,728	38,047	43,339	50,349	D	690	850	120	672	1392	2112
HE-11-R —	9680	9251	440	2464	5104	7744	96.8	193.6	387	11,801	14,538	17,371	A	1200	1400	115	644	1334	2024
SOLAR PHYSICS				—															
N SO-01-S —	12,362	12,362	259.6	1454	3012	4569	123.2	246.4	495	13,680	15,361	17,166	A	702	1217	63.15	354	733	1111
ATMOSPHERIC AND SPACE PHYSICS																			
N AP-06-S —	11,838	10,243	187	1047	2169	3291	118.8	237.6	473	12,817	14,058	15,415	A	2525	4249	394	2206	4570	6934
EARTH OBSERVATIONS																			
N EO-01-S —	1753	1753	151.8	849	1760	2671	158.4	385	701.8	2609	3746	4974	D	400	660	2.3	13	27	40
N EO-05-S —	16,350	16,350	1087	6085	12,606	19,127	162.8	328	653	21,511	28,197	35,043	A	1880	2018	231	1294	2680	4066
N EO-06-S —	1144	1144	561	3142	6508	9874	22	57.2	114.4	3747	7148	10,571	B	914	914	19	106	220	334
N EO-07-S —	975	975	44	2464	510	774	19.8	48.4	96.8	1197	1489	1802	B	264	1082	32	179	371	563
EARTH AND OCEAN PHYSICS																			
N OP-02-S —	3234	3234	550	3080	6380	9680	129.8	356	647	5894	9420	13,011	C	2192	3018	197	1103	2285	3467

WEIGHT AND ENERGY (IN SI) (SHEET AIV-2)

PAYLOAD	7 DAYS LAUNCH WT(Kg)	7 DAYS DOWN WT(Kg)	CONSUMABLES (Kg) 7	CONSUMABLES (Kg) 30	CONSUMABLES (Kg) 60	CONSUMABLES (Kg) 90	SPARES (Kg) 30	SPARES (Kg) 60	SPARES (Kg) 90	TOTAL WEIGHT (Kg) 30	TOTAL WEIGHT (Kg) 60	TOTAL WEIGHT (Kg) 90	SPARES CODE
ASTRONOMY													
N AS-01-S —	3296	3143	561	3142	6505	9874	33	66	132	5910	[illegible]	[illegible]	A
N AS-03-S —	3774	3774	—	—	—	—	38	75	151	[illegible]	[illegible]	[illegible]	A
N AS-04-S —	1836	1683	262	1467	3039	4611	18	37	73	[illegible]	4650	[illegible]	A
AS-08-S —	554	504	50	280	580	880	11	22	55	795	1112	1439	B
AS-10-S —	426	406	20	112	232	352	4	9	17	522	647	775	A
AS-13-S —	20	20	—	—	—	—	2	4	8	[illegible]	24	[illegible]	D
N AS-15-S —	5326	5266	241	1350	2796	4242	107	266	533	6542	8147	9860	B
AS-19-S —	1000	950	50	280	580	880	10	20	40	1240	1550	1870	A
AS-31-S —	8009	6867	1142	6395	13,247	20,099	160	400	801	13,422	20,514	27,767	B
AS-54-S —	7017	6107	964	5398	11,182	16,966	140	351	702	11,591	17,586	23,721	B
AS-01-R —	4400	4205	200	1120	2320	3520	44	88	176	5364	6608	7896	A
HIGH ENERGY ASTROPHYSICS													
HE-14-S —	4687	4647	40	224	464	704	47	94	187	4918	5205	5538	A
HE-19-S —	1814	1764	50	280	580	880	18	36	73	2062	2380	2717	A
N HE-X-S —	15,600	15,600	63	353	731	1109	1404	3432	6240	17,294	19,700	22,886	D
HE-11-R —	4400	4205	200	1120	2320	3520	44	88	176	5364	6608	7896	A
SOLAR PHYSICS													
N SO-01-S —	5619	5619	118	661	1369	2077	56	112	225	[illegible]	[illegible]	7803	A
ATMOSPHERIC AND SPACE PHYSICS													
N AP-06-S —	5381	4656	85	476	986	1496	54	108	215	5826	[illegible]	7007	A
EARTH OBSERVATIONS													
N EO-01-S —	797	797	69	386	800	1214	72	175	319	1186	1703	2261	D
N EO-05-S —	7432	7432	494	2766	5730	8694	74	149	297	9778	12,317	15,929	A
N EO-06-S —	520	520	255	1428	2958	4488	10	26	52	1703	3249	4805	B
N EO-07-S —	443	443	20	112	232	352	9	22	44	544	677	819	B
EARTH AND OCEAN PHYSICS													
N OP-02-S —	1470	1470	250	1400	[illegible]	4400	57	162	294	2679	[illegible]	[illegible]	C

PAYLOAD	POWER (W) AVERAGE	POWER (W) PEAK	ENERGY (KWHR) 7	ENERGY (KWHR) 30	ENERGY (KWHR) 60	ENERGY (KWHR) 90
ASTRONOMY						
N AS-01-S —	944	[illegible]	148	829	1717	2605
N AS-03-S —	992	1207	172	963	1995	3027
N AS-04-S —	400	500	58	325	673	1021
AS-08-S —	100	150	14.4	81	167	253
AS-10-S —	400	452	62	347	719	1091
AS-13-S —	[illegible]	20	0.28	1.6	3.2	4.9
N AS-15-S —	944	1162	148	829	1717	2605
AS-19-S —	400	500	58	325	673	1021
AS-31-S —	2429	3367	371	2078	4304	6530
AS-54-S —	1392	1897	201	1126	2332	3538
AS-01-R —	1200	1400	115	644	1334	2024
HIGH ENERGY ASTROPHYSICS						
HE-14-S —	360	360	56	314	650	986
HE-19-S —	356	450	55.5	311	644	977
N HE-X-S —	690	850	120	672	1392	2112
HE-11-R —	1200	1400	115	644	1334	2024
SOLAR PHYSICS						
N SO-01-S —	702	1217	63.15	354	733	1111
ATMOSPHERIC AND SPACE PHYSICS						
N AP-06-S —	2525	4249	394	2206	4570	6934
EARTH OBSERVATIONS						
N EO-01-S —	400	660	2.3	13	27	40
N EO-05-S —	1880	2015	231	1294	2680	4066
N EO-06-S —	714	714	19	106	220	334
N EO-07-S —	264	1082	32	179	371	563
EARTH AND OCEAN PHYSICS						
N OP-02-S —	2192	3018	177	1103	2285	3467

WEIGHT AND ENERGY (IN ENGLISH) (SHEET AIV-3)

PAYLOAD		7 DAYS LAUNCH WT (LBS)	7 DAYS DOWN WT (LBS)	CONSUMABLES (LBS) 7	30	60	90	SPARES (LBS) 30	60	90	TOTAL WEIGHT (LBS) 30	60	90	SPARES CODE	POWER (W) AVERAGE	PEAK	ENERGY (KW HR) 7	30	60	90
EARTH AND OCEAN PHYS																				
N OP-03-S	—	1393	1393	469	2625	5436	8248	28.6	70.4	138.6	3578	6430	9311	B	350	438	18	101	209	317
N OP-04-S	—	854	854	151.8	849	1760	2671	8.8	17.6	35.2	1560	2480	3498	A	475	559	20	112	232	352
N OP-05-S	—	3234	3234	550	3080	6380	9680	129.8	356	647	5894	9420	13,011	C	2192	3018	197	1103	2285	3467
N OP-06-S	—	755	755	112.2	629	1302	1976	15.4	37.4	74.8	1287	1982	2694	B	560	868	51	286	592	898
SPACE PROCESSING																				
SP-01-S	—	5[illegible]	5042	493	2759	5716	8672	103.4	255.2	513	7484	10,593	13,807	B	4360	5800	260	1456	3016	4576
SP-05-S	—	15,587	15,371	1542	8637	17,890	27,144	623	1714	3117	23,305	33,649	44,306	C	9970	22,000	1130	6328	13,108	19,888
N SP-14-S	—	14,003	13,856	1049	5876	12,173	18,469	279	700	1401	19,109	25,827	32,824	B	9970	22,000	1130	6328	13,108	19,888
SP-15-S	—	10,795	10,652	986	5520	11,433	17,347	107.8	215.6	431	15,437	21,458	27,587	A	6360	20,360	860	4816	9976	15,136
SP-16-S	—	6862	6785	557	3117	6457	9797	275	755	1373	9697	13,517	17,475	C	3850	5800	360	2016	4176	6336
SP-19-S	—	12,745	12,668	1049	5876	12,173	18,469	255.2	638	1274	17,827	24,507	31,439	B	5770	20,770	970	5432	11,252	17,072
LIFE SCIENCES																				
LS-04-S	—	759	682	77	431	893	1355	30.8	83.6	151.8	1144	1659	2189	C	445	689	4.3	24	50	76
LS-09-S	W/OUT CENTRIFUGE	5564	5564	438	2451	5078	7704	502	1223	2226	8079	11,427	15,056	D	2507	3500	358	2005	4153	6301
	WITH CENTRIFUGE	6261	5564	438	2451	5078	7704	563	1377	2504	8837	12,278	16,031	D	2507	3700	358	2005	4153	6301
LS-10-S	—	574	574	—	—	—	—	22	63.8	114.4	596	638	688	C	756	1099	49.5	277	574	871
N LS-X-S		20,999	TBD	788	4411	9139	13,869	840	2310	4200	25,462	31,660	38,280	C	8	10	1346	7538	15,614	23,690
SPACE TECHNOLOGY																				
ST-04-S	—	1415	1065	350	1958	4057	6156	57.2	156.2	283.8	3080	5278	7505	C	497	650	15.8	88	183	278
ST-05-S	—	968	917	57.2	321	664	1008	88	213.4	387	1320	1788	2306	D	453	800	16.2	91	188	285
ST-06-S	—	1368	1353	15.4	85.8	178.2	270.6	206.8	301	548	1645	1832	2171	D	304	530	11.4	64	132	201
ST-08-S	—	116.6	116.6	6.6	41.8	85.8	129.8	2.2	6.6	11	154	202.4	250.8	B	147	147	26	146	302	458
N ST-21-S	—	2977	2911	187	1047	2169	3291	118.8	328	596	3956	5287	6677	C	430	1447	104	582	1206	1830
ST-22-S	—	5126	5060	202.4	1133	2347	3562	204.6	563	1025	6261	7834	9511	C	574	1160	98	549	1137	1725
ST-23-S	—	7102	7102	—	—	—	—	283.8	781	1421	7386	7883	8523	C	2100	2340	242	1355	2807	4259
COMMUNICATIONS AND NAVIGATION																				
N CN-02-S	—	4301	4301	—	—	—	—	85.8	215.6	431	4387	4517	4732	B	2100	7000	126	706	1462	2218
CN-04-S	—	636	636	50.6	283.8	587	891	57.2	140.8	255.2	926	1313	1732	D	1068	1068	17	95	197	299
CN-06-S	—	1492	1492	26.4	147.4	305.8	464	116.6	165	299.2	1730	1936	2229	C	1460	2244	19.6	110	227	345

WEIGHT AND ENERGY (IN SI) (SHEET AIV-4)

PAYLOAD	7 DAYS LAUNCH WT (Kg)	7 DAYS DOWN WT (Kg)	CONSUMABLES (Kg) 7	30	60	90	SPARES (Kg) 30	60	90	TOTAL WEIGHT (Kg) 30	60	90	SPARES CODE			POWER (W) AVERAGE	PEAK	ENERGY (KW HR) 7	30	60	90		
EARTH AND OCEAN PHYS																							
N OP-03-S —	633	633	213	1193	2471	3749	13	32	63	1676	2713	4233	B			55	43[illegible]	[illegible]	161	209	317		
N OP-04-S —	388	388	69	356	800	1214	4	8	16	709	1127	1549	A			475	557	20	112	232	352		
N OP-05-S —	1470	1470	250	1400	2900	4400	5[illegible]	162	274	2679	42[illegible]	5[illegible]	C			2192	3018	197	1103	2285	3467		
N OP-06-S —	343	343	51	286	[illegible]	898	7	[illegible]	34	5[illegible]5	901	12[illegible]4	B			560	468	51	286	592	898		
SPACE PROCESSING																							
SP-01-S —	2325	2292	224	1254	2598	[illegible]142	47	116	[illegible]	3[illegible]2	4815	[illegible]76	B			4360	5800	260	1456	[illegible]016	4576		
SP-05-S —	7085	69[illegible]	701	3926	8132	12,338	283	779	1417	10,[illegible]73	[illegible]	[illegible]	C			9970	22,500	113[illegible]	[illegible]328	13,108	17,888		
SP-14-S —	6365	6778	477	2691	5533	[illegible]	[illegible]7	318	[illegible]	[illegible]	11,[illegible]	14,920	B			9970	22,500	1130	6328	13,108	17,888		
N SP-15-S —	4907	4842	448	2509	5197	7885	49	78	[illegible]76	7017	9754	12,540	A			6360	20,360	860	4816	9976	15,136		
SP-16-S —	3119	3084	253	1417	2935	4453	125	343	[illegible]	4[illegible]	6144	9943	C			3850	5800	360	2016	4176	6336		
SP-19-S —	5973	5958	477	2671	5533	8395	116	240	579	8[illegible]3	11,137	14,280	B			5770	29,770	970	5432	11,252	17,072		
LIFE SCIENCES																							
LS-04-S —	345	310	35	196	406	616	14	38	69	520	754	995	C			445	689	4.3	24	50	76		
LS-09-S W/OUT CENTRIFUGE	2529	2529	199	1114	2308	3502	228	556	1012	3672	5194	6844	D			2507	3500	358	2005	4153	6301		
LS-09-S WITH CENTRIFUGE	2846	2529	199	1114	2308	3502	256	626	1138	4017	5581	7287	D			2707	3700	358	2005	4153	6301		
LS-10-S —	261	261	—	—	—	—	10	29	52	271	290	313	C			756	1099	49.5	277	574	871		
N LS-X-S	9545	TBD	358	2005	4159	6304	382	1050	1909	11,574	14,391	17,400	C			8	10	1346	7538	15,614	23,690		
SPACE TECHNOLOGY																							
ST-04-S —	693	484	159	890	1844	2798	26	71	129	1045	2399	3411	C			497	650	15.8	88	183	278		
ST-05-S —	440	417	26	146	302	458	40	97	176	600	813	1048	D			453	800	16.2	91	188	285		
ST-06-S —	622	615	7	39	81	123	74	137	249	748	833	987	D			304	530	11.4	64	132	201		
ST-08-S —	53	53	3	19	39	59	1	3	5	70	92	114	B			147	147	26	146	302	458		
N ST-21-S —	1353	1323	85	476	986	1496	54	149	271	1798	2403	3035	C			430	1447	104	582	1206	1830		
ST-22-S —	2330	2300	92	515	1067	1619	93	256	466	2846	3561	4323	C			574	1160	98	549	1137	1725		
ST-23-S —	3228	3228	—	—	—	—	129	355	646	3359	3583	3874	C			2100	2340	242	1355	2807	4259		
COMMUNICATIONS AND NAVIGATION																							
N CN-02-S —	1955	1955	—	—	—	—	39	98	196	1994	2053	2151	B			2100	7000	126	706	1462	2218		
CN-04-S —	289	289	23	129	267	405	26	64	116	421	597	787	D			1068	1068	17	95	197	299		
CN-06-S —	678	678	12	67	139	211	53	75	136	786	880	1013	C			1460	2244	19.6	110	227	345		

time equals flight time minus one day up and one day down. Consequently, a 7-day flight has 5 days operation time, a 30-day flight has 28 days, a 60-day flight has 58 days, and a 90-day flight has 88 days.

8-10. The requirements for spares become more important as an extended mission is undertaken. These columns indicate weight for these spares as a percentage of payload launch weight. Each payload is assigned a spares group and the appropriate factor is applied as shown in Table A-1. The group assigned depends on type and size of payload hardware, complexity, amount of pressurized and unpressurized equipment, type of support equipment, and type and quantity of consumables.

11-13. These columns indicate total payload weight for 30-, 60-, and 90-day flights assuming payload operation consistent with the 7-day flight specified in the SSPDA.

14. Spares group (A, B, C, or D).

15-16. Intentionally blank.

17-18. These columns indicate the basic power requirements for each payload. The average power level is that required while operating on orbit. The peak power is the highest occasional, short-duration peaks that occur during operation.

Table A-1

PERCENT OF PAYLOAD WEIGHT TO BE SPARED

Group	30 Days	60 Days	90 Days
A	1	2	4
B	2	5	10
C	4	11	20
D	9	22	40

19. This column indicates the energy required for a 7-day flight.

20-22. These columns indicate the energy required for 30-, 60-, and 90-day flights. These values are extrapolated from the energy requirements for a 7-day flight in the same manner as the weight of consumables (Columns 5-7).

23,24. Intentionally blank.

VOLUME REQUIREMENTS

Sheets AV-1 through -4 compile the volume requirements for each payload, both in English units and the International System of units (SI). Identification of the codes used on these sheets is as follows, reading the 24 columns from left to right:

1. Payload identification number per SSPDA, July 1974. An "N" preceding the number identifies the payload as one recommended by the NASA study panel.

2. This column indicates the pallet length required by unpressurized equipment.

3. This column identifies the volume of payload equipment to be installed in a pressurized area, not including access space.

4-7. These columns indicate the volume of pressurized area required to store the data recorded on orbit to be returned to Earth. The 7-day value is determined by applying volume factors to the various types of data requirements specified in the SSPDA. The volumes for 30-, 60-, and 90-day flights are extrapolated from the 7-day value assuming consistent flight operations. It is assumed that payload operation time equals flight time minus one day up and one day down. Consequently, a 7-day flight has 5 days operation time, a 30-day flight has 28 days, a 60-day flight has 58 days, and a 90-day flight has 88 days.

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VOLUME (IN ENGLISH) (SPARES AV-1)

PAYLOAD	PALLET LENGTH FT	PRESSURIZED VOLUME (FT³) PAYLOAD EQUIPMENT	DATA				OTHERS				TOTAL VOLUME				UNPRESSURIZED VOLUME (FT³) PAYLOAD EQUIPMENT	OTHERS				TOTAL VOLUME			
			7	30	60	90	7	30	60	90	7	30	60	90		7	30	60	90	7	30	60	90
ASTRONOMY																							
N AS-01-S —	15.1	32.81	6.886	38.14	80.16	122.2	—	—	—	—	39.7	70.95	112.97	155	715	46.[illegible]	[illegible]	604	905	762	1017	1319	1620
N AS-03-S —	19.7	20.84	1.211	6.42	11.082	19.63	—	—	—	—	22.05	27.26	31.92	40.47	578	—	—	—	—	578	578	578	578
N AS-04-S —	13.1	11.477	3.779	20.55	42.55	64.17	—	—	—	—	15.26	32.03	54.03	75.65	366					366	366	366	366
AS-08-S —	4.9	10.594	1.130	6.357	12.713	17.42	—	—	—	—	11.74	16.95	23.31	30.01	17.66	—	—			17.66	17.66	17.66	17.66
AS-10-S —	3.3	10.594	149.0	833	1,722	2,615	—	—	—	—	159.6	841	1733	2626	17.66	—	—	—	—	17.66	17.66	17.66	17.66
AS-13-S —	0.16	0.999	0.018	0.106	0.212	0.353	—	—	—	—	1.017	1.105	1.211	1.352	3.531	—			—	3.531	3.531	3.531	3.531
N AS-15-S —	36.1	30.02	6.89	38.14	81.58	124	—	—	—	—	36.71	68.16	111.6	154	3275	32.4	211	422	633	3307	3486	3697	3908
AS-19-S —	9.8	10.594	29.66	166	343	523	—	—	—	—	40.25	176.6	354	534	282.5	—	—	—	—	282.5	282.5	282.5	282.5
AS-31-S —	39.4	56.15	12.713	69.75	145.14	219.7	—	—	—	—	68.86	125.9	201.3	275.9	1667	46.6	302	604	905	1714	1969	2271	2572
AS-54-S —	32.8	28.78	4.59	25.60	54.03	81.22	—	—	—	—	33.37	54.38	82.81	110	944	—	—	—	—	944	944	944	944
AS-01-R —	13.1	10.594	5.65	30.37	62.15	94.64	—	—	—	—	16.24	40.96	72.74	105.2	1236	FOR	ALL	EQUIPMENT		1236	1236	1236	1236
HIGH ENERGY ASTROPHYSICS																							
HE-14-S —	16.4	14.83	3.178	18.364	37.79	56.5	—	—	—	—	18.01	33.19	52.62	71.33	606	0.06	0.35	0.74	1.09	606	606	607	607
HE-19-S —	11.5	15.009	4.026	23.308	48.38	72.75	—	—	—	—	19.04	38.05	63.39	87.76	127.8	—	—	—	—	127.8	127.8	127.8	127.8
N HE-X-S —	39.4	5650	FOR	ALL	EQUIPMENT		—	—	—	—	5650	5650	5650	5650	—	—	—	—	—	—	—	—	—
HE-11-R —	13.1	10.594	106.7	602	1249	1895	—	—	—	—	117.3	613	1260	1906	1236	FOR	ALL	EQUIPMENT		1236	1236	1236	1236
SOLAR PHYSICS																							
N SO-01-S —	44.9	97.12	2036	11,402	23,610	35,841	—	—	—	—	2133	11,499	23,707	35,938	901	—	—	—	—	901	901	901	901
ATMOSPHERIC AND SPACE PHYSICS																							
N AP-06-S —	24.9	112.1	128.2	712	1475	2235	—	—	—	—	240.3	824	1587	2347	1362	1.483	8.264	17.09	25.92	1363	1370	1379	1388
EARTH OBSERVATIONS																							
N EO-01-S —	—	311	0.53	3.178	6.357	9.535	62.36	118.7	191.1	223.5	374	433	508	544	—	—	—	—	—	—	—	—	—
N EO-05-S —	59.1	6.286	4.238	24.014	49.79	76.6[illegible]	—	—	—	—	10.52	30.3	56.08	82.92	5771	—	—	—	—	5771	5771	5771	5771
N EO-06-S —	7.2	2.119	0.071	0.353	0.706	1.06	—	—	—	—	2.19	2.47	2.83	3.18	101.71	—	—	—	—	101.71	101.71	101.71	101.71
N EO-07-S —	6.6	25.07	0.106	0.141	0.283	0.424	—	—	—	—	25.18	25.2	25.35	25.49	17.66	—	—	—	—	17.66	17.66	17.66	17.66
EARTH AND OCEAN PHYSICS																							
N OP-02-S —	2	87.93	34.47	192.8	398	604	—			—	122.4	280.7	486	692	244.7	—	—	—	—	244.7	244.7	244.7	244.7

VOLUME (IN SI) (SHEET AV-2)

PAYLOAD	PALLET LENGTH m	PRESSURIZED VOLUME (m³): PAYLOAD EQUIPMENT	DATA 7	DATA 30	DATA 60	DATA 90	OTHERS 7	OTHERS 30	OTHERS 60	OTHERS 90	TOTAL VOLUME 7	TOTAL VOLUME 30	TOTAL VOLUME 60	TOTAL VOLUME 90	UNPRESSURIZED VOLUME (m³): PAYLOAD EQUIPMENT	OTHERS 7	OTHERS 30	OTHERS 60	OTHERS 90	TOTAL VOLUME 7	TOTAL VOLUME 30	TOTAL VOLUME 60	TOTAL VOLUME 90
ASTRONOMY																							
N AS-01-S —	4.6	0.929	0.195	1.08	2.27	3.46	—	—	—	—	1.12	2.01	3.2	4.39	20.241	1.32	8.55	17.09	25.63	21.55	28.79	37.33	45.87
N AS-03-S —	6	0.59	0.0343	0.1818	0.3138	0.5558	—	—	—	—	0.62	0.77	0.96	1.33	16.37	—	—	—	—	16.37	16.37	16.37	16.37
N AS-04-S —	4	0.325	0.107	0.582	1.205	1.817	—	—	—	—	0.43	0.91	1.53	2.14	10.35	—	—	—	—	10.35	10.35	10.35	10.35
AS-08-S —	1.5	0.3	0.032	0.18	0.36	0.55	—	—	—	—	0.33	0.48	0.66	0.85	0.5	—	—	—	—	0.5	0.5	0.5	0.5
AS-10-S —	1	0.3	4.22	23.58	48.77	74.06	—	—	—	—	4.52	23.88	49.07	74.31	0.5	—	—	—	—	0.5	0.5	0.5	0.5
AS-13-S —	0.05	0.0283	0.0005	0.003	0.005	0.01	—	—	—	—	0.028	0.031	0.034	0.038	0.1	—	—	—	—	0.1	0.1	0.1	0.1
N AS-15-S —	11	0.85	0.195	1.08	2.31	3.51	—	—	—	—	1.05	1.93	3.16	4.36	92.73	0.92	5.98	11.95	17.93	93.65	98.71	104.68	110.66
AS-19-S —	3	0.3	0.84	4.7	9.7	14.8	—	—	—	—	1.14	5	10	15.1	8	—	—	—	—	8	8	8	8
AS-31-S —	12	1.59	0.36	1.975	4.11	6.22	—	—	—	—	1.95	3.57	5.7	7.81	47.2	1.32	8.55	17.09	25.63	48.52	55.75	64.29	72.83
AS-54-S —	10	0.815	0.13	0.725	1.53	2.3	—	—	—	—	0.95	1.54	2.35	3.12	26.72	—	—	—	—	26.72	26.72	26.72	26.72
AS-01-R —	4	0.3	0.16	0.86	1.76	2.68	—	—	—	—	0.46	1.16	2.06	2.98	35	FOR ALL EQUIPMENT				35	35	35	35
HIGH ENERGY ASTROPHYSICS																							
HE-14-S —	5	0.42	0.09	0.52	1.07	1.6	—	—	—	—	0.51	0.94	1.49	2.02	17.15	0.0017	0.0099	0.021	0.031	17.152	17.15	17.17	17.18
HE-19-S —	3.5	0.425	0.114	0.66	1.37	2.06	—	—	—	—	0.54	1.09	1.8	2.49	3.62	—	—	—	—	3.62	3.62	3.62	3.62
N HE-X-S —	12	160	FOR ALL EQUIPMENT				—	—	—	—	160	160	160	160	—	—	—	—	—	—	—	—	—
HE-11-R —	4	0.3	3.02	17.06	35.36	53.65	—	—	—	—	3.32	17.36	35.66	53.95	35	FOR ALL EQUIPMENT				35	35	35	35
SOLAR PHYSICS																							
N SO-01-S —	13.7	2.75	57.65	322.88	668.57	1014.9	—	—	—	—	60.4	325.63	671.32	1017.7	25.5	—	—	—	—	25.5	25.5	25.5	25.5
ATMOSPHERIC AND SPACE PHYSICS																							
N AP-06-S —	7.6	3.174	3.63	20.17	41.78	63.3	—	—	—	—	6.8	23.34	44.95	66.47	38.572	0.042	0.234	0.484	0.734	38.61	38.8	39.06	39.31
EARTH OBSERVATIONS																							
N EO-01-S —	—	8.8	0.015	0.09	0.18	0.27	1.78	3.36	5.41	6.33	10.6	12.25	14.39	15.4	—	—	—	—	—	—	—	—	—
N EO-05-S —	18	0.178	0.12	0.68	1.41	2.17	—	—	—	—	0.3	0.86	1.59	2.35	163.43	—	—	—	—	163.4	163.4	163.4	163.4
N EO-06-S —	2.1	0.06	0.002	0.01	0.02	0.03	—	—	—	—	0.06	0.07	0.08	0.09	2.88	—	—	—	—	2.88	2.88	2.88	2.88
N EO-07-S —	2	0.71	0.003	0.004	0.008	0.012	—	—	—	—	0.71	0.71	0.72	0.72	0.5	—	—	—	—	0.5	0.5	0.5	0.5
EARTH AND OCEAN PHYSICS																							
N OP-02-S —	0.6	2.41	0.976	5.46	11.27	17.09	—	—	—	—	3.47	7.95	13.76	19.58	6.9293	—	—	—	—	6.93	6.93	6.93	6.93

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VOLUME (IN ENGLISH) (SHEET AV-3)

PAYLOAD	PALLET LENGTH FT	PRESSURIZED VOLUME (FT3): PAYLOAD EQUIPMENT	DATA 7	DATA 30	DATA 60	DATA 90	OTHERS 7	OTHERS 30	OTHERS 60	OTHERS 90	TOTAL VOLUME 7	TOTAL VOLUME 30	TOTAL VOLUME 60	TOTAL VOLUME 90
EARTH AND OCEAN PHYS														
N OP-03-S —	9.8	6.498	0.812	3.955	9.182	13.77	—	—	—	—	7.31	10.45	15.68	20.27
N OP-04-S —	3.6	9.005	2.504	14.656	30.72	46.47	—	—	—	—	11.51	23.66	39.73	55.48
N OP-05-S —	2	87.93	34.47	192.8	398	604	—	—	—	—	122.4	280.7	486	692
N OP-06-S —	2	21.99	8.687	48.03	99.59	151.5	—	—	—	—	30.68	70.02	121.6	173.5
SPACE PROCESSING														
SP-01-S —	4.3	115.9	0.028	0.177	0.353	0.53	17.66	98.88	204.8	311	133.6	215	321	427
SP-05-S —	12.1	342	0.706	6.251	12.47	18.72	624	3,492	7,232	10,983	967	3840	7586	11,344
N SP-14-S —	8	230	3.18	18.36	38.14	57.56	35.31	197.8	410	622	268	446	678	910
SP-15-S —	4.3	9.5	3.18	16.95	35.31	52.97	—	—	—	—	12.68	26.45	44.81	62.47
SP-16-S —	8	230	0.035	0.283	0.60	0.883	35.31	197.8	410	622	265	428	641	852
SP-19-S —	8	173.3	3.18	16.95	35.31	52.97	17.66	98.88	204.8	311	194.1	289.1	413	537
LIFE SCIENCES														
LS-04-S —	5	61.09	—	—	—	—	—	—	—	—	61.09	61.09	61.09	61.09
LS-09-S W/OUT CENTRIFUGE	—	544	1.61	44.60	93.48	141.96	6.25	28.25	63.21	95.7	552	617	701	782
LS-09-S WITH CENTRIFUGE		883	1.61	44.60	93.48	141.96	8.19	39.2	79.81	120.4	893	967	1056	1145
LS-10-S —	—	50.85	2.30	12.64	26.02	38.23	0.424	2.01	3.52	6.00	53.57	65.5	80.39	95.08
N LS-X-S	—	1589	3.14	80.16	168.1	255.7	14.76	70.63	143.7	216.8	1607	1740	1901	2062
SPACE TECHNOLOGY														
ST-04-S —	16.4	25.39	146.2	832	1,721	2,613	6.957	38.49	80.87	122.5	178.5	896	1827	2761
ST-05-S —	—	124.7	372	2,079	4,319	6,516	10.382	58.269	120.4	182.9	507	2262	4564	6824
ST-06-S —	—	129.3	1.554	8.829	18.010	27.192	0.346	0.957	4.026	6.145	131.8	139.1	151	162.6
ST-08-S —	2.3	0	1.059	5.650	12.007	18.010	—	—	—	—	1.06	5.65	12.07	18.01
N ST-21-S —	19.7	222.5	20.482	116.19	237.3	360	1.766	10.10	20.73	31.11	244.7	349	481	614
ST-22-S —	19.7	134.9	499	2,780	5,774	8,769	2.179	11.76	24.37	37.08	636	2927	5933	8941
ST-23-S —	49.2	141.96	6.463	37.08	76.28	115.8	—	—	—	—	148.4	179.0	218.2	257.8
COMMUNICATIONS AND NAVIGATION														
N CN-02-S —	TBD	600	14.161	44.5	164.6	250.4	—	—	—	—	614	645	765	850
CN-04-S —	5.2	12.36	6.039	33.443	72.64	105.1	—	—	—	—	18.4	45.8	85.0	117.5
CN-06-S —	9.8	70.28	0.184	1.448	2.225	3.673	—	—	—	—	70.5	71.7	72.5	74.0

PAYLOAD	UNPRESSURIZED VOLUME (FT3): PAYLOAD EQUIPMENT	OTHERS 7	OTHERS 30	OTHERS 60	OTHERS 90	TOTAL VOLUME 7	TOTAL VOLUME 30	TOTAL VOLUME 60	TOTAL VOLUME 90
EARTH AND OCEAN PHYS									
N OP-03-S —	66.74	—	—	—	—	66.74	66.74	66.74	66.74
N OP-04-S —	34.89	—	—	—	—	34.89	34.89	34.89	34.89
N OP-05-S —	244.7	—	—	—	—	244.7	244.7	244.7	244.7
N OP-06-S —	30.01	—	—	—	—	30.01	30.01	30.01	30.01
SPACE PROCESSING									
SP-01-S —	—	—	—		—	—	—	—	—
SP-05-S —	212.9	459	2 612	5 370	8 121	672	2825	5583	8334
N SP-14-S —	212.9	459	2 612	5 370	8 121	672	2825	5583	8334
SP-15-S —	506	37.43	209.8	434	659	543	716	940	1165
SP-16-S —	0	115.13	644	1 334	2 024	115.13	644	1 334	2 024
SP-19-S —	212.9	459	2 612	5 370	8 121	672	2825	5583	8334
LIFE SCIENCES									
LS-04-S —	40.61	—	—	—	—	40.61	40.61	40.61	40.61
LS-09-S W/OUT CENTRIFUGE	—	—	—	—	—	—	—	—	—
LS-09-S WITH CENTRIFUGE	—	—	—	—	—	—	—	—	—
LS-10-S —	—	—	—	—	—	—	—	—	—
N LS-X-S	—	—	—	—			—	—	—
SPACE TECHNOLOGY									
ST-04-S —	3.037	—	—	—	—	3.037	3.037	3.037	3.037
ST-05-S —	—	—	—	—	—	—	—	—	—
ST-06-S —	—	—	—	—	—	—	—	—	—
ST-08-S —	3.471	—	—	-	—	3.471	3.471	3.471	3.471
N ST-21-S —	944	—	—	—	—	944	944	944	944
ST-22-S —	415	—	—	—	—	415	415	415	415
ST-23-S —	1418	—	—	—	—	1418	1418	1418	1418
COMMUNICATIONS AND NAVIGATION									
N CN-02-S —	617	—	—	—	—	617	617	617	617
CN-04-S —	249	—	—	—	—	249	249	249	249
CN-06-S —	353	—	—	—	—	353	353	353	353

VOLUME (IN SI) (SHEET AV-4)

PAYLOAD	PALLET LENGTH m	PRESSURIZED VOLUME (m3) PAYLOAD EQUIPMENT	DATA 7	DATA 30	DATA 60	DATA 90	OTHERS 7	OTHERS 30	OTHERS 60	OTHERS 90
EARTH AND OCEAN PHYS										
N OP-03-S —	3	0.184	0.023	0.112	0.26	0.39	—	—	—	—
N OP-04-S —	1.1	0.255	0.0709	0.415	0.87	1.316	—	—	—	—
N OP-05-S —	0.6	2.49	0.776	5.46	11.27	17.09	—	—	—	—
N OP-06-S —	0.6	0.6226	0.246	1.36	2.82	4.29	—	—	—	—
SPACE PROCESSING										
SP-01-S —	1.3	3.283	0.0008	0.005	0.01	0.015	0.5	2.8	5.8	8.8
SP-05-S —	3.7	9.69	0.1	0.59	1.22	1.85	1	5.6	11.6	17.6
N SP-14-S —	2.45	6.513	0.09	0.52	1.08	1.63	1	5.6	11.6	17.6
SP-15-S —	1.3	0.269	0.09	0.48	1	1.5	—	—	—	—
SP-16-S —	2.45	6.513	0.001	0.008	0.017	0.025	1	5.6	11.6	17.6
SP-19-S —	2.45	4.907	0.09	[illegible]	1	1.5	0.5	2.8	5.8	8.8
LIFE SCIENCES										
LS-04-S —	1.53	1.73	–	–	–	–	–	–	–	–
LS-09-S W/OUT CENTRIFUGE	—	15.4	0.0456	1.263	2.647	4.02	0.177	0.8	1.79	2.71
LS-09-S WITH CENTRIFUGE		25	0.0456	1.263	2.647	4.02	0.232	1.11	2.26	3.41
LS-10-S —	—	1.44	0.0652	0.3578	0.7367	1.0826	0.012	0.057	0.1	0.17
N LS-X-S	—	45	0.089	2.27	4.76	7.24	0.418	2	4.07	6.14
SPACE TECHNOLOGY										
ST-04-S —	5	0.719	4.14	23.56	48.73	74	0.197	1.104	2.29	3.47
ST-05-S —	—	3.53	10.53	58.86	122.3	184.5	0.294	1.65	3.41	5.18
ST-06-S —	—	3.66	0.044	0.25	0.51	0.77	0.0098	0.0271	0.114	0.174
ST-08-S —	0.71	0	0.03	0.16	0.34	0.51	—	—	—	—
N ST-21-S —	6	6.3	0.58	3.29	6.72	10.2	0.05	0.286	0.587	0.898
ST-22-S —	6	3.82	14.13	78.72	163.5	248.3	0.06	0.333	0.69	1.05
ST-23-S —	15	4.02	0.183	1.05	2.16	3.28	—	—	—	—
COMMUNICATIONS AND NAVIGATION										
N CN-02-S —	TBD	17	0.401	1.26	4.66	7.09	—	—	—	—
CN-04-S —	1.6	0.35	0.171	0.947	2.057	2.976	—	—	—	—
CN-06-S —	3	1.99	0.0052	0.041	0.063	0.104	—	—	—	—

PAYLOAD	PRESSURIZED TOTAL VOLUME 7	TOTAL VOLUME 30	TOTAL VOLUME 60	TOTAL VOLUME 90	UNPRESSURIZED VOLUME (m3) PAYLOAD EQUIPMENT	OTHERS 7	OTHERS 30	OTHERS 60	OTHERS 90	TOTAL VOLUME 7	TOTAL VOLUME 30	TOTAL VOLUME 60	TOTAL VOLUME 90
EARTH AND OCEAN PHYS													
N OP-03-S —	0.21	0.3	0.44	0.57	1.89	—	—	—	—	1.89	1.89	1.89	1.89
N OP-04-S —	0.33	0.67	1.13	1.57	0.985	—	—	—	—	0.988	0.988	0.988	0.988
N OP-05-S —	3.47	7.95	13.76	19.58	6.9293	—	—	—	—	6.93	6.93	6.93	6.93
N OP-06-S —	0.87	1.98	3.44	4.91	0.8497	—	—	—	—	0.85	0.85	0.85	0.85
SPACE PROCESSING													
SP-01-S —	3.6	6.1	9.1	11.1	—	—	—	—	—	—	—	—	—
SP-05-S —	10.8	15.7	22.5	29.1	6.03	13	73.96	152.07	229.97	19.03	79.99	158.1	236
N SP-14-S —	7.6	12.6	19.2	25.7	6.03	13	73.96	152.07	229.97	19.03	79.99	158.1	236
SP-15-S —	0.278	0.749	1.269	1.769	14.34	1.06	5.94	12.3	18.66	15.4	20.28	26.64	33
SP-16-S —	7.6	12.6	19.2	25.7	0	3.26	18.24	37.78	57.3	3.26	18.24	37.78	57.3
SP-19-S —	5.5	8.2	11.7	15.2	6.03	13	73.96	152.07	229.97	19.03	79.99	158.1	236
LIFE SCIENCES													
LS-04-S —	1.73	1.73	1.73	1.73	1.15	—	—	—	—	1.15	1.15	1.15	1.15
LS-09-S W/OUT CENTRIFUGE	15.62	17.46	19.14	22.13	—	—	—	—	—	—	—	—	—
LS-09-S WITH CENTRIFUGE	25.27	27.37	29.91	32.43	—	—	—	—	—	—	—	—	—
LS-10-S —	1.517	1.855	2.277	2.693	—	—	—	—	—	—	—	—	—
N LS-X-S	45.51	49.27	53.8	58.4	—	—	—	—	—	—	—	—	—
SPACE TECHNOLOGY													
ST-04-S —	5.06	25.38	51.71	78.19	0.086	—	—	—	—	0.086	0.086	0.086	0.086
ST-05-S —	14.35	64.04	129.2	193.2	—	—	—	—	—	—	—	—	—
ST-06-S —	3.714	3.94	4.28	4.6	—	—	—	—	—	—	—	—	—
ST-08-S —	0.03	0.16	0.34	0.51	0.0983	—	—	—	—	0.99	0.99	0.99	0.99
N ST-21-S —	7.39	9.88	13.61	17.4	26.729	—	—	—	—	26.73	26.73	26.73	26.73
ST-22-S —	18.01	82.87	168	253.2	11.764	—	—	—	—	11.764	11.764	11.764	11.764
ST-23-S —	4.2	5.07	6.18	7.3	40.164	—	—	—	—	40.164	40.164	40.164	40.164
COMMUNICATIONS AND NAVIGATION													
N CN-02-S —	17.4	18.26	21.66	24.09	17.46	—	—	—	—	17.46	17.46	17.46	17.46
CN-04-S —	0.52	1.3	2.41	3.33	7.05	—	—	—	—	7.05	7.05	7.05	7.05
CN-06-S —	2	2.03	2.05	2.09	10	—	—	—	—	10	10	10	10

ORIGINAL PAGE IS OF POOR QUALITY

The storage volume of film required was determined by multiplying the required number of frames by the following factors:

a)	35 mm	0.0006 m^3	Per 1,000 frames
b)	70 mm	0.001 m^3	Per 1,000 frames
c)	200 mm	0.003 m^3	Per 1,000 frames
d)	16 mm	0.00067 m^3	Per 10,000 frames
		or 0.0005 m^3	Per reel (7,500 frames)

Factors a, b, and d were determined by using data obtained from Skylab ICD 13M13519. Experiment and Operational film to OW5 Film Vault, Stowage Requirements. This ICD describes the stowage requirements and film cassettes and magazines for all of the Skylab experience using the film vault. For factor a, a 35-mm 50-frame cassette requires a volume of 1.7 in^3 = 0.0001 ft^3 = 0.00003 m^3. Therefore, 1,000 frames require 0.0006 m^3.

For factor b, a 70-mm 500-frame cassette requires a volume of 28.9 in^3 = 0.017 ft^3 = 0.0005 m^3. Therefore, 1,000 frames require 0.001 m^3.

Factor c was computed by multiplying factor b by 2.

For factor d, a 16-mm 400-ft cassette requires a volume = 27.2 in^3 = 0.015 ft^3 = 0.0005 m^3. A 400-ft cassette is 120,000 mm. For 16 mm film this would be 7,500 frames. Therefore, 10,000 frames would require 0.00067 m^3.

Each reel is 0.0005 m^3.

It should be noted that no volume is allowed in the estimates for the film vault if required to provide protection for unexposed and exposed film.

8-11. The volumes for other consumables (contained in a pressurized area) are indicated in these columns for 7-, 30-, 60-, and 90-day flights. These volumes are calculated in the same manner as those for data (Columns 3-6).

12-15. These columns indicate total volume required in the pressurized area for 7-, 30-, 60-, and 90-day flights.

16. This column identifies the volume of payload equipment to be installed in an unpressurized area.

17-20. The volumes for consumables (contained in an unpressurized area) required to support the payload are included in these columns. These values are calculated in the same manner as the pressurized volumes (Columns 12-15).

21-24. These columns indicate total volume required in the unpressurized area for 7-, 30-, 60-, and 90-day flights.

ENVIRONMENTAL REQUIREMENTS

Sheets AVI-1 through -4 compile the environmental requirements for each payload, in English units and in the International System of units (SI), and potential hazardous conditions that could, in event of equipment failure, result in injury to personnel or cause damage to other equipment. Identification of the codes used on these sheets is as follows, reading the 24 columns from left to right:

1. Payload identification number per SSPDA, July 1974. An "N" preceding the number identifies the payload as one recommended by the NASA study team.

2-3. The cleanliness (class) requirements for the pressurized and unpressurized equipment are identified in these columns.

4-7. The maximum and minimum temperatures for the payload pressurized and unpressurized equipment is provided in these columns. These temperatures are at the payload-Spacelab/Orbiter interface.

8. This column identifies the maximum allowable relative humidity.

9. This column indicates the allowable overall acoustic levels. (0 db = 20 $\mu N/m^2$).

ENVIRONMENTAL (IN ENGLISH) (SHEET AVI-1)

PAYLOAD	CLEANLINESS CLASS PRESS	CLEANLINESS CLASS UNPRESS	TEMPERATURE °R PRESSURIZED MAX	TEMPERATURE °R PRESSURIZED MIN	TEMPERATURE °R UNPRESSURIZED MAX	TEMPERATURE °R UNPRESSURIZED MIN	MAX HUMIDITY %	MAX ACOUSTIC LEVEL dB	MAXIMUM RADIATION RATE mRAD/HR PRESS	MAXIMUM RADIATION RATE mRAD/HR UNPRESS	TOTAL RADS	POTENTIAL HAZARDS FROM PAYLOAD	POTENTIAL HAZARDS TO PAYLOAD
ASTRONOMY													
N AS-01-S —	100K	1K	537	518	522	486	40	60	3.85	0.98	.29	CRYOGENS	OPTICAL CONTAM EMI
N AS-03-S —	100K	1K	529	515	662	392	40	60		0.98	.72	TOXIC GAS HIGH VOLTAGE	OPTICAL CONTAM
N AS-04-S —	100K	1K	539	519	544	508	40	60		7.8	1.8E-03	HIGH PRESS HIGH VOLTAGE	OPTICAL CONTAM EMI
AS-08-S —	100K	1K	538	517	540	468	40	70		0.98		HIGH PRESS	OPTICAL CONTAM
AS-10-S —	100K	1K	536	518	509	508	40	70		0.009		HIGH PRESS	OPTICAL CONTAM
AS-13-S —	100K	5K	536	518	650	358	40	80		9.8			OPTICAL CONTAM
N AS-15-S —	100K	1K	536	518	504	360	40	60		0.98	1.8E-03	CRYOGENS	OPTICAL CONTAM EMI
AS-19-S —	100K	1K	536	518	540	468	40	80		0.009			OPTICAL CONTAM
AS-31-S —	100K	1K	536	518	522	486	40	60		0.98		HIGH PRESS CRYOGENS	OPTICAL CONTAM
AS-54-S —	100K	1K	537	518	662	392	40	60		0.98		HIGH PRESS	OPTICAL CONTAM
AS-01-R —	100K	1K	536	518	545	509	40	80		0.98		HIGH PRESS	OPTICAL CONTAM
HIGH ENERGY ASTROPHYSICS													
HE-14-S —	100K	100K	536	518	527	491	40	80		0.78			
HE-19-S —	100K	1K	538	517	545	491	40	60		0.98		HIGH PRESS	
N HE-X-S —	100K	N/A	545	509	N/A	N/A	40	80	N/A	N/A		HIGH PRESS HIGH MAGNETIC FIELDS HIGH VOLTAGE	EMULSION FOGGING
HE-11-R —	100K	1K	536	518	527	491	40	60		0.98		HIGH PRESS	OPTICAL CONTAM
SOLAR PHYSICS													
N SO-01-S —	N/A	10K	527	518	527	524	25	70		10.85	1.9	CRYOGENS	OPTICAL CONTAM EMI
ATMOSPHERIC AND SPACE PHYSICS													
N AP-06-S —	100K	50K	536	491	497	491	40	70	16.8	21.35	2	HIGH PRESS CRYOGENS PYROS HIGH RF HIGH VOLTAGE LASERS MECHANISMS	OPTICAL CONTAM EMI
EARTH OBSERVATIONS													
N EO-01-S —	20K	N/A	540	504	N/A	N/A	70	56	59,500	N/A	300	HIGH VOLTAGE HIGH RF	DEPOSITION OF WATER OR HYDROCARBONS ON SENSORS
N EO-05-S —	N/A	N/A	549	500	549	531	70	70	2905	2905	500	HIGH VOLTAGE	DEPOSITION OF WATER OR HYDROCARBONS ON SENSORS
N EO-06-S —	10K	10K	540	500	523	522	70	150	2905	2905	500		
N EO-07-S —	100K	100K	540	518	536	518	70	120	2870	52,500		HIGH VOLTAGE LASER	
EARTH AND OCEAN PHYSICS													
N OP-02-S —	100K	100K	540	500	540	500	70	150	5.95	5.95	1	HIGH VOLTAGE HIGH RF	OPTICAL CONTAM

ENVIRONMENTAL (IN SI) (SHEET AVI-2)

PAYLOAD	CLEANLINESS CLASS PRESS	CLEANLINESS CLASS UNPRESS	TEMPERATURE °K PRESSURIZED MAX	TEMPERATURE °K PRESSURIZED MIN	TEMPERATURE °K UNPRESSURIZED MAX	TEMPERATURE °K UNPRESSURIZED MIN	MAX HUMIDITY %	MAX ACOUSTIC LEVEL dB	MAXIMUM RADIATION RATE J/Kg·S PRESS	MAXIMUM RADIATION RATE J/Kg·S UNPRESS	MAXIMUM RADIATION TOTAL J/Kg		POTENTIAL HAZARDS FROM PAYLOAD	POTENTIAL HAZARDS TO PAYLOAD
ASTRONOMY														
N AS-01-S —	100K	1K	298.5	287.5	290	270	40	60	1.1E-08	2.8E-09	2.9E-03		CRYOGENS	OPTICAL CONTAM EMI
N AS-03-S —	100K	1K	294	286	368	218	40	60		2.8E-09	7.2E-03		TOXIC GAS HIGH VOLTAGE	OPTICAL CONTAM
N AS-04-S —	100K	1K	299.5	288.5	302	282	40	60		2.8E-08	1.8E-05		HIGH PRESS HIGH VOLTAGE	OPTICAL CONTAM EMI
AS-08-S —	100K	1K	299	287	300	260	40	70		2.8E-09			HIGH PRESS	OPTICAL CONTAM
AS-10-S —	100K	1K	298	288	283	282	40	70		2.8E-11			HIGH PRESS	OPTICAL CONTAM
AS-13-S —	100K	5K	298	288	361	199	40	80		2.8E-08				OPTICAL CONTAM
N AS-15-S —	100K	1K	298	288	280	200	40	60		2.8E-09	1.8E-03		CRYOGENS	OPTICAL CONTAM EMI
AS-19-S —	100K	1K	298	288	300	260	40	80		2.8E-11				OPTICAL CONTAM
AS-31-S —	100K	1K	298	288	290	270	40	60		2.8E-09			HIGH PRESS CRYOGENS	OPTICAL CONTAM
AS-54-S —	100K	1K	298.5	287.5	368	218	40	60		2.8E-09			HIGH PRESS	OPTICAL CONTAM
AS-01-R —	100K	1K	298	288	303	283	40	80		2.8E-09			HIGH PRESS	OPTICAL CONTAM
HIGH ENERGY ASTROPHYSICS														
HE-14-S —	100K	100K	298	288	293	273	40	80		2.8E-09				
HE-19-S —	100K	1K	299	287	303	273	40	60		2.8E-09			HIGH PRESS	
N HE-X-S —	100K	N/A	303	283	N/A	N/A	40	80	N/A	N/A	N/A		HIGH PRESS HIGH VOLTAGE HIGH MAGNETIC FIELDS	EMULSION FOGGING
HE-11-R —	100K	1K	298	288	293	273	40	80		2.8E-09			HIGH PRESS	OPTICAL CONTAM
SOLAR PHYSICS														
N SO-01-S —	N/A	10K	293	288	292	291	25	70		3.1E-08	1.9E-02		CRYOGENS	OPTICAL CONTAM EMI
ATMOSPHERIC AND SPACE PHYSICS														
N AP-06-S —	100K	50K	298	273	276	273	40	70	4.8E-08	6.1E-08	2E-02		HIGH PRESS CRYOGENS PYROS HIGH RF HIGH VOLTAGE LASERS MECHANISMS	OPTICAL CONTAM EMI
EARTH OBSERVATIONS														
N EO-01-S —	20K	N/A	300	280	N/A	N/A	70	56	1.7E-04	N/A	3		HIGH VOLTAGE HIGH RF	DEPOSITION OF WATER OR HYDROCARBONS ON SENSORS
N EO-05-S —	N/A	N/A	305	278	305	295	70	70	8.3E-06	8.3E-06	5		HIGH VOLTAGE	DEPOSITION OF WATER OR HYDROCARBONS ON SENSORS
N EO-06-S —	10K	10K	300	278	290.4	290	70	150	8.3E-06	8.3E-06	5			
N EO-07-S —	100K	100K	300	288	298	288	70	120	8.2E-06	1.5E-04			HIGH VOLTAGE LASER	
EARTH AND OCEAN PHYSICS														
N OP-02-S —	100K	100K	300	278	300	278	70	150	1.7E-08	1.7E-08	1E-02		HIGH VOLTAGE HIGH RF	OPTICAL CONTAM

ENVIRONMENTAL (IN ENGLISH) (SHEET AVI-3)

	CLEANLINESS CLASS		TEMPERATURE °R				MAX HUMIDITY	MAX ACOUSTIC LEVEL	MAXIMUM RADIATION			POTENTIAL HAZARDS FROM PAYLOAD	POTENTIAL HAZARDS TO PAYLOAD
			PRESSURIZED		UNPRESSURIZED				RATE RADIAL		TOTAL		
	PRESS	UNPRESS	MAX	MIN	MAX	MIN	%	dB	PRESS	UNPRESS	RADS		
EARTH AND OCEAN PHYS													
N OP-03-S —	100K	100K	563	491	549	509	70	150	2905	2905	500	HIGH VOLTAGE HIGH RF	OPTICAL CONTAM
N OP-04-S —	N/A	N/A	563	500	549	509	N/A	N/A	N/A	2905	500	PYROS HIGH RF	OPTICAL CONTAM DEPOSITION OF WATER OR HYDROCARBONS ON SENSORS
N OP-05-S —	100K	100K	540	500	540	500	70	150	5.98	5.98	1	HIGH VOLTAGE HIGH RF	OPTICAL CONTAM
N OP-06-S —	100K	100K	563	500	549	500	70	150	2905	2905	500	HIGH VOLTAGE HIGH RF LASER	OPTICAL CONTAM
SPACE PROCESSING													
SP-01-S —	100K	N/A	536	526	603	180	70	80	N/A	N/A		HIGH PRESS CRYOGENS	
SP-05-S —	100K	N/A	536	526	603	180	70	80	N/A	N/A		HIGH PRESS CRYOGENS HIGH VOLTAGE LASER HIGH TEMP BIOLOGICAL SPECIMENS	MAGNETIC FIELD
N SP-14-S —	100K	N/A	536	526	603	180	70	80	N/A	N/A	N/A	HIGH PRESS CRYOGENS HIGH VOLTAGE LASER BIOLOGICAL SPECIMENS	MAGNETIC FIELD
SP-15-S —	100K	100K	536	526	603	180	70	80	N/A	N/A	N/A	HIGH PRESS CRYOGENS HIGH VOLTAGE HIGH TEMP	
SP-16-S —	100K	N/A	536	526	603	180	70	80	N/A	N/A		HIGH PRESS CRYOGENS HIGH VOLTAGE LASER BIOLOGICAL SPECIMENS	MAGNETIC FIELD
SP-19-S —	100K	N/A	536	526	603	180	70	80	N/A	N/A		HIGH PRESS CRYOGENS HIGH VOLTAGE LASER BIOLOGICAL SPECIMENS	MAGNETIC FIELD
LIFE SCIENCES													
LS-04-S —	100K	100K	540	518	571	459	60	80		N/A		HIGH PRESS TOXIC GAS COLLISION	
LS-09-S —	100K	N/A	542	531	N/A	N/A	60	55		N/A		HIGH PRESS CRYOGENS TOXIC GAS HIGH TEMP RADIOBIOLOGY CENTRIFUGE	
LS-10-S —	100K	N/A	542	531	N/A	N/A	60	80		N/A		TOXIC GAS BIOLOGICAL SPECIMENS	
N LS-X-S	100K	N/A	542	531	N/A	N/A	60	80		N/A		HIGH PRESS CRYOGENS TOXIC GAS BIOLOGICAL SPECIMENS RADIOISOTOPES	
SPACE TECHNOLOGY													
ST-04-S —	100K		560	500	610	500	95	60		N/A		HIGH PRESS HIGH TEMP	
ST-05-S —	100K	N/A	560	500	N/A	N/A	95	60		N/A		HIGH PRESS CRYOGENS	
ST-06-S —	100K	N/A	560	500	N/A	N/A	95	60		N/A		HIGH TEMP FLUIDS PRESSURE CHAMBER	
ST-08-S —	N/A	N/A	N/A	N/A	610	500	N/A	N/A	N/A	N/A			
N ST-21-S —	100K		560	500	610	500	95	60		N/A		HIGH VOLTAGE LASER BIOLOGICAL SPECIMENS	OPTICAL CONTAM
ST-22-S —	100K		560	500	610	500	95	60				HIGH VOLTAGE HIGH TEMP HIGH RF BIOLOGICAL SPECIMENS	OPTICAL CONTAM MAGNETIC FIELD
ST-23-S —	100K		560	500	610	500	95	60				HIGH VOLTAGE HIGH RF LASER	OPTICAL CONTAM
COMMUNICATIONS AND NAVIGATION													
N CN-02-S —	100K	100K	540	504	540	504	50	N/A			1.7E-02	HIGH VOLTAGE HIGH RF LASER	
CN-04-S —	100K	100K	540	500	563	491	70	150	2870	51,800	500		
CN-06-S —	100K	100K	540	500	563	500	70	150	2870	2870		HIGH VOLTAGE HIGH RF	

A-28

ENVIRONMENTAL (IN SI) (SHEET AVI-4)

PAYLOAD	CLEANLINESS CLASS PRESS	CLEANLINESS CLASS UNPRESS	TEMPERATURE °K PRESSURIZED MAX	TEMPERATURE °K PRESSURIZED MIN	TEMPERATURE °K UNPRESSURIZED MAX	TEMPERATURE °K UNPRESSURIZED MIN	MAX HUMIDITY %	MAX ACOUSTIC LEVEL dB	MAXIMUM RADIATION RATE J/Kg·S PRESS	MAXIMUM RADIATION RATE J/Kg·S UNPRESS	MAXIMUM RADIATION TOTAL J/Kg	POTENTIAL HAZARDS FROM PAYLOAD	POTENTIAL HAZARDS TO PAYLOAD
EARTH AND OCEAN PHYS													
N OP-03-S —	100K	100K	313	273	305	283	70	150	8.3E-06	8.3E-06	5	HIGH VOLTAGE HIGH RF	OPTICAL CONTAM
N OP-04-S —	N/A	N/A	313	278	305	283	N/A	N/A	N/A	8.3E-06	5	PYROS HIGH RF	OPTICAL CONTAM DEPOSITION OF WATER OR HYDROCARBONS ON SENSORS
N OP-05-S —	100K	100K	300	278	300	278	70	150	1.7E-08	1.7E-08	1E-02	HIGH VOLTAGE HIGH RF	OPTICAL CONTAM
N OP-06-S —	100K	100K	313	278	305	278	70	150	8.3E-06	8.3E-06	5	HIGH VOLTAGE HIGH RF LASER	OPTICAL CONTAM
SPACE PROCESSING													
SP-01-S —	100K	N/A	298	292	335	100	70	80	N/A	N/A		HIGH PRESS CRYOGENS	
SP-05-S —	100K	N/A	298	292	335	100	70	80	N/A	N/A		HIGH PRESS CRYOGENS HIGH VOLTAGE LASER HIGH TEMP BIOLOGICAL SPECIMENS	MAGNETIC FIELD
N SP-14-S —	100K	N/A	298	292	335	100	70	80	N/A	N/A	N/A	HIGH PRESS CRYOGENS HIGH VOLTAGE LASER BIOLOGICAL SPECIMENS	MAGNETIC FIELD
SP-15-S —	100K	100K	298	292	335	100	70	80	N/A	N/A	N/A	HIGH PRESS CRYOGENS HIGH VOLTAGE HIGH TEMP	
SP-16-S —	100K	N/A	298	292	335	100	70	80	N/A	N/A		HIGH PRESS CRYOGENS HIGH VOLTAGE LASER BIOLOGICAL SPECIMENS	MAGNETIC FIELD
SP-19-S —	100K	N/A	298	292	335	100	70	80	N/A	N/A		HIGH PRESS CRYOGENS HIGH VOLTAGE LASER BIOLOGICAL SPECIMENS	MAGNETIC FIELD
LIFE SCIENCES													
LS-04-S —	100K	100K	300	288	317	255	60	80		N/A		HIGH PRESS TOXIC GAS COLLISION	
LS-09-S —	100K	N/A	301	295	N/A	N/A	60	55		N/A		HIGH PRESS CRYOGENS TOXIC GAS HIGH TEMP RADIOBIOLOGY CENTRIFUGE	
LS-10-S —	100K	N/A	301	295	N/A	N/A	60	80		N/A		TOXIC GAS BIOLOGICAL SPECIMENS	
N LS-X-S	100K	N/A	301	295	N/A	N/A	60	80		N/A		HIGH PRESS CRYOGENS TOXIC GAS BIOLOGICAL SPECIMENS RADIOISOTOPES	
SPACE TECHNOLOGY													
ST-04-S —	100K		311	278	339	278	95	60		N/A		HIGH PRESS HIGH TEMP	
ST-05-S —	100K	N/A	311	278	N/A	N/A	95	60		N/A		HIGH PRESS CRYOGENS	
ST-06-S —	100K	N/A	311	278	N/A	N/A	95	60		N/A		HIGH TEMP FLUIDS PRESSURE CHAMBER	
ST-08-S —	N/A	N/A	N/A	N/A	339	278	N/A	N/A	N/A	N/A			
N ST-21-S —	100K		311	278	339	278	95	60		N/A		HIGH VOLTAGE LASER BIOLOGICAL SPECIMENS	OPTICAL CONTAM
ST-22-S —	100K		311	278	339	278	95	60				HIGH VOLTAGE HIGH TEMP HIGH RF BIOLOGICAL SPECIMENS	OPTICAL CONTAM MAGNETIC FIELD
ST-23-S —	100K		311	278	339	278	95	60				HIGH VOLTAGE HIGH RF LASER	OPTICAL CONTAM
COMMUNICATIONS AND NAVIGATION													
N CN-02-S —	100K	100K	300	280	300	280	50	N/A			1.7E-04	HIGH VOLTAGE HIGH RF LASER	
CN-04-S —	100K	100K	300	278	313	273	70	150	8.2E-06	8.2E-05	5		
CN-06-S —	100K	100K	300	278	313	278	70	150	8.2E-06	8.2E-06		HIGH VOLTAGE HIGH RF	

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10-12. These columns indicate the maximum allowable radiation rates and total allowable radiation that the payload equipment can tolerate. The use of "E" refers to exponent (i.e., IE-03 is 1×10^{-3}).

13,14. Intentionally blank.

15-20. These columns identify potential hazards from the payload that, in the event of failure, could cause injury to personnel or damage to other equipment.

21-24. These columns identify potential hazards that could affect satisfactory operation of the payload.

SPACE PROCESSING PAYLOADS

In addition to the 46 original SSPDA payloads identified for additional study, four new payloads were identified. These space processing payloads were not analyzed separately for MOSC impact but only in combination, identified as C19 in Section C of this appendix. These four payloads are:

SP-1X-S Production of Surface Acoustic Wave Components
SP-2X-S Production of High Ductility Tungsten
SP-3X-S Separation of Iso-Enzymes
SP-4X-S Solar Furnace for Production of Semiconductor Silicon Ribbon

LIFE SCIENCE PAYLOADS

In addition to the three life science payloads included in the SSPDA documentation, a special data sheet on the Long-Duration Life Science Payload (LS-X) was provided and is included.

SORTIE PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. SP-X1-S

PAYLOAD NAME PRODUCTION OF SURFACE ACOUSTIC WAVE COMPONENTS

DEVELOPMENT AGENCY NASA

PREPARATION DATE Dec.11,1974 REVISION DATE 2-5-75 LTR A

PURPOSE PRODUCTION OF ELECTRONIC CIRCUIT COMPONENTS

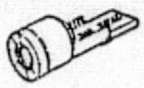
DISCIPLINE

- ☐ ASTRONOMY
- ☐ HIGH-ENERGY ASTROPHYSICS
- ☐ SOLAR PHYSICS
- ☐ ATMOSPHERIC & SPACE PHYSICS
- ☐ EARTH OBSERVATIONS
- ☐ EARTH & OCEAN PHYSICS
- ☒ SPACE PROCESSING
- ☐ LIFE SCIENCES
- ☐ SPACE TECHNOLOGY
- ☐ COMM/NAV.
- ☐ OTHER (SPECIFY)

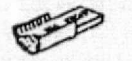
PAYLOAD TYPE/MODE

☒ MODULE

☐ MODULE/PALLET



☐ PALLET



☐ ON-ORBIT CONTROL
☐ GROUND CONTROL
☐ CARRY-ON

DESIRED TIME ON-ORBIT: 90 (2) DAYS

NO. OF MISSIONS PER YEAR

CY	79	80	81	82	83	84	85	86	87	88	89	90	91
SORTIE						1	1	1	1	1	1	1	1

OPERATIONAL ORBIT, CHARACTERISTICS

	DESIRED	MINIMUM	MAXIMUM
ALTITUDE, APOGEE, km	ANY		
ALTITUDE, PERIGEE, km	ANY		
INCLINATION, deg	ANY		

MAJOR INSTRUMENTS/EQUIPMENT

NAME	DESCRIPTION	MEASUREMENT OBJECTIVE/FUNCTION
Engraver/ Microscope	Electron beam etcher & scanning microscope	Engrave lithium niobate slabs to controlled 100 Å space (1 M^3)
Control Console	Contain controls, monitors & displays	Control engraver and scanning electron beam microscope. (1 M^3)
Storage Containers	Contain raw materials and finished products	Provides protection and storage space for lithium niobate raw stock and finished products. Contain 800,000 units approx. 1 mm x 1 mm x 2 mm (.16 M^3, 50 Kgm)

SPECIAL REQUIREMENTS/ASSUMPTIONS

REFERENCE DOCUMENTS

Discussions; MSFC, GE and MDAC personnel at MSFC, November 22, 1974

SORTIE PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. SP-X1-S

PAYLOAD NAME PRODUCTION OF SURFACE ACOUSTIC WAVE COMPONENTS PAYLOAD MODEL CODE NO. (NEW)

+ PHYSICAL CHARACTERISTICS OF P/L	WEIGHT, kg
+ TOTAL P/L AT LAUNCH, kg	470
• PRESSURIZED EQUIP., kg	420
• UNPRESSURIZED EQUIP., kg	0
• CONSUMABLES AT LAUNCH, kg	50
• EXPENDED CONSUMABLES & EQUIP. NOT RETURNED TO EARTH, kg	420 (1)
• EST. PALLET LENGTH, m	
• PRESSURIZED EQUIP. VOL, m^3	2.16

+ ENVIRONMENTAL REQ'MTS IN-FLIGHT (MODE / LOCATION)	OPERATING PRESS	OPERATING UNPRESS	NON-OPERATING PRESS	NON-OPERATING UNPRESS
• TEMP LIMIT, °K · MAX	ambient			
· MIN				
• HUMIDITY %	ambient			
• CLEANLINESS CLASS	UNK			
• ACOUSTIC LIMIT, dB OVERALL	UNK			
• ACCELERATION LIMIT, g	10^{-4}			
• RADIATION RATE LIMIT, J/kg-s				

REQUIREMENTS ON SHUTTLE/SPACELAB

+ PAYLOAD PERSONNEL
- ESTIMATED NUMBER OF P/L PERSONNEL 1
- TOTAL P/L PERSONNEL TIME, hr/day 4
- TOTAL P/L PERSONNEL TIME, hr/mission 280 (2)
- P/L PERSONNEL OPERATION 1 SHIFT [X] 2 SHIFTS [ ]
- NO. OF PLANNED EVA 0
- AVERAGE DURATION OF EVA, hr 0
- CONTINGENCY EVA YES [ ] NO [X]

+ PAYLOAD POWER – IN FLIGHT

	DC (W)	AC (W)
• AVERAGE POWER	0	780
• PEAK POWER	0	1000
• ASCENT/DESCENT PWR	0	0

PEAK POWER DURATION, hr Continuous – 70 days
TOTAL ENERGY, kWhr 1680
AC FREQUENCY 60 Hz [X] 400 Hz [ ] OTHER [ ]

+ DATA/COMMUNICATIONS – ON ORBIT
- IS USE OF TDRS ASSUMED? YES [ ] NO [X]
- VOICE – UP YES [X] NO [ ] – DOWN YES [ ] NO [X]
- PHOTO FILM STORAGE WEIGHT, kg

	STORED	DOWN RT*	DOWN DUMP*	UP
• DIGITAL				
RATE (MAX), b/s	1000	1000		
DURATION, hr/opn		.1		
hr/day	.1	.1		
TOTAL, Mb/day		.36		
Mb/mission	.36			
• ANALOG				
BANDWIDTH (MAX), MHz				
DURATION, hr/opn				
hr/day				
TOTAL DURATION, hr/msn				
• TV COLOR, hr/day				
BLACK & WHITE, hr/day				

+ POINTING (SHUTTLE/SPACELAB)
- ACCURACY, arc sec NR (3)
  - DURATION, hr/opn max
  - REPETITION RATE, opn/day
  - TOTAL POINTING TIME, hr/mission
- STABILITY, arc sec NR (3)
  - DURATION, hr/opn max
- STABILITY RATE, arc sec/sec NR (3)
- VIEWING CONSTRAINTS NR
- ORIENTATION NR (3)

+ SUPPORT/INTEG. EQUIP. REQ'D (NOT PROVIDED BY P/L)
- SPECIAL GIMBAL MOUNT/ POINTING PLATFORM? YES [ ] NO [X]
  TYPE EST. WEIGHT, kg

	QTY	TYPE/SIZE
• AIRLOCK	0	
• BOOM	0	
• VIEWPORT	0	
• OTHER	1	Access to vacuum of space

+ TIME CRITICAL ACCESS ON GROUND	TIME (HR)	DURATION (HR)	PURPOSE
• BEFORE LAUNCH	0		
• AFTER LAUNCH	0		

+ POTENTIAL HAZARDS (CHECK)
- [ ] HIGH PRESSURE BOTTLES
- [ ] PYROTECHNICS
- [ ] OTHER
- [ ] TOXIC GASES
- [ ] CRYOGENICS

+ COMMENTS (1) Engraver and console can be left in space, (2) operations active for 70 days, (3) no specific requirement for pointing so long as the 10-4 vibration free environment is maintained.

+ COMPUTER SUPPORT REQ'D YES [ ] NO [X]
- MAX WORD LENGTH ______ BITS
- BULK MEMORY SIZE ______ WORDS
- RAPID ACCESS MEMORY SIZE ______ WORDS
- NO. OF COMPUTATIONS PER SECOND ______ MAX
- COMPUTER FUNCTIONS:

SPD (LA-2) 4/74

* RT = real time; DUMP = data dumped to ground within one day.

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SORTIE PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. SP-X2-S

PAYLOAD NAME PRODUCTION OF HIGH DUCTILITY TUNGSTEN

DEVELOPMENT AGENCY NASA

PREPARATION DATE Dec.11,1974 REVISION DATE 2-5-75 LTR A

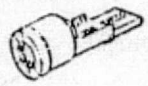
PURPOSE PRODUCTION OF X-RAY TUBE TARGETS

DISCIPLINE

- [ ] ASTRONOMY
- [ ] HIGH-ENERGY ASTROPHYSICS
- [ ] SOLAR PHYSICS
- [ ] ATMOSPHERIC & SPACE PHYSICS
- [ ] EARTH OBSERVATIONS
- [ ] EARTH & OCEAN PHYSICS
- [x] SPACE PROCESSING
- [ ] LIFE SCIENCES
- [ ] SPACE TECHNOLOGY
- [ ] COMM/NAV.
- [ ] OTHER (SPECIFY)

PAYLOAD TYPE/MODE

[x] MODULE 

[ ] MODULE/PALLET 

[ ] PALLET 

[ ] ON-ORBIT CONTROL

[ ] GROUND CONTROL

[ ] CARRY-ON

DESIRED TIME ON-ORBIT 90(3) DAYS

NO. OF MISSIONS PER YEAR

CY	79	80	81	82	83	84	85	86	87	88	89	90	91
SORTIE						1	1	1	1	1	1	1	1

OPERATIONAL ORBIT, CHARACTERISTICS

	DESIRED	MINIMUM	MAXIMUM
ALTITUDE, APOGEE, km	ANY		
ALTITUDE, PERIGEE, km	ANY		
INCLINATION, deg	ANY		

MAJOR INSTRUMENTS/EQUIPMENT

NAME	DESCRIPTION	MEASUREMENT OBJECTIVE/FUNCTION
Furnace	Levitated melt e.b. furnace	Melts tungsten in levitated state in electron beam furnace
Control Console	Contains controls, monitors & displays	Controls furnace
Storage containers	contain raw materials and finished products	Provides protection and storage space for tungsten target material (150 Kgm. .1 M^3)

SPECIAL REQUIREMENTS/ASSUMPTIONS

REFERENCE DOCUMENTS

Discussion/ MSFC, GE and MDAC personnel at MSFC, November 22, 1974

SORTIE PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. SP-X2-S

PAYLOAD NAME PRODUCTION OF HIGH DUCTILITY TUNGSTEN PAYLOAD MODEL CODE NO. (NEW)

♦ PHYSICAL CHARACTERISTICS OF P/L	WEIGHT, kg
♦ TOTAL P/L AT LAUNCH, kg	550
• PRESSURIZED EQUIP., kg	400
• UNPRESSURIZED EQUIP., kg	0
• CONSUMABLES AT LAUNCH, kg	150
• EXPENDED CONSUMABLES & EQUIP. NOT RETURNED TO EARTH, kg	400(1)
• EST. PALLET LENGTH, m	
• PRESSURIZED EQUIP. VOL, m^3	1.6

♦ ENVIRONMENTAL REQ'MTS IN-FLIGHT (MODE / LOCATION)	OPERATING PRESS	OPERATING UNPRESS	NON-OPERATING PRESS	NON-OPERATING UNPRESS
• TEMP LIMIT, °K - MAX	ambient			
- MIN				
• HUMIDITY %	ambient			
• CLEANLINESS CLASS	UNK			
• ACOUSTIC LIMIT, dB OVERALL	UNK			
• ACCELERATION LIMIT, g	10^{-3}			
• RADIATION RATE LIMIT, J/kg-s	NR			

REQUIREMENTS ON SHUTTLE/SPACELAB

♦ PAYLOAD PERSONNEL

- ESTIMATED NUMBER OF P/L PERSONNEL 1
- TOTAL P/L PERSONNEL TIME, hr/day 4
- TOTAL P/L PERSONNEL TIME, hr/mission 280 (3)
- P/L PERSONNEL OPERATION 1 SHIFT [X] 2 SHIFTS [ ]
- NO. OF PLANNED EVA 0
- AVERAGE DURATION OF EVA, hr 0
- CONTINGENCY EVA YES [ ] NO [X]

♦ PAYLOAD POWER – IN FLIGHT

	DC (W)	AC (W)
• AVERAGE POWER		4700
• PEAK POWER		7000
• ASCENT/DESCENT PWR		0

PEAK POWER DURATION, hr 1436

TOTAL ENERGY, kWhr 10,296

AC FREQUENCY 60 Hz [X] 400 Hz [ ] OTHER [ ]

♦ DATA/COMMUNICATIONS – ON ORBIT

- IS USE OF TDRS ASSUMED? YES [ ] NO [X]
- VOICE – UP YES [ ] NO [X] – DOWN YES [ ] NO [X]
- PHOTO FILM STORAGE WEIGHT, kg 0

	STORED	DOWN RT*	DOWN DUMP*	UP
• DIGITAL				
RATE (MAX), b/s		100		
DURATION, hr/opn		-		
hr/day		1		
TOTAL, Mb/day		NIL		
Mb/mission	NIL			
• ANALOG				
BANDWIDTH (MAX), MHz	-			
DURATION, hr/opn				
hr/day				
TOTAL DURATION, hr/msn				
• TV COLOR, hr/day	-			
BLACK & WHITE, hr/day				

♦ POINTING (SHUTTLE/SPACELAB).

- ACCURACY, arc sec NR(2)
  - DURATION, hr/opn max
  - REPETITION RATE, opn/day
  - TOTAL POINTING TIME, hr/mission
- STABILITY, arc sec NR(2)
  - DURATION, hr/opn max
- STABILITY RATE, arc sec/sec NR(2)
- VIEWING CONSTRAINTS NR
- ORIENTATION NR

♦ SUPPORT/INTEG. EQUIP. REQ'D (NOT PROVIDED BY P/L)

- SPECIAL GIMBAL MOUNT/ POINTING PLATFORM? YES [ ] NO [X]

TYPE EST. WEIGHT, kg

	QTY	TYPE/SIZE
• AIRLOCK	0	
• BOOM	0	
• VIEWPORT	0	
• OTHER	1	Access to vacuum of space

♦ TIME CRITICAL ACCESS ON GROUND	TIME (HR)	DURATION (HR)	PURPOSE
• BEFORE LAUNCH			
• AFTER LAUNCH			

♦ POTENTIAL HAZARDS (CHECK)

[ ] HIGH PRESSURE BOTTLES [ ] TOXIC GASES
[ ] PYROTECHNICS [ ] CRYOGENICS
[ ] OTHER

♦ COMMENTS (1) Furnace and controls can be left in space, (2) no specific pointing requirements so long as 10^{-3} vibration free environment maintained, (3) active period - 70 days.

♦ COMPUTER SUPPORT REQ'D YES [ ] NO [X] • RAPID ACCESS MEMORY SIZE WORDS
• MAX WORD LENGTH BITS • NO. OF COMPUTATIONS PER SECOND MAX
• BULK MEMORY SIZE WORDS • COMPUTER FUNCTIONS:

SSPD (LA-2) 4/74

* RT = real time; DUMP = data dumped to ground within one day.

SORTIE PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. SP-X3-S

PAYLOAD NAME SEPARATION OF ISO ENZYMES

DEVELOPMENT AGENCY NASA

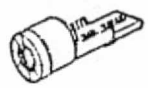
PREPARATION DATE Dec. 11, 1974 REVISION DATE 2-5-75 LTR A

PURPOSE PRODUCTION OF ISOENZYME BIOLOGICALS

DISCIPLINE
☐ ASTRONOMY
☐ HIGH-ENERGY ASTROPHYSICS
☐ SOLAR PHYSICS
☐ ATMOSPHERIC & SPACE PHYSICS
☐ EARTH OBSERVATIONS
☐ EARTH & OCEAN PHYSICS
☒ SPACE PROCESSING
☐ LIFE SCIENCES
☐ SPACE TECHNOLOGY
☐ COMM/NAV.
☐ OTHER (SPECIFY)

PAYLOAD TYPE/MODE

☒ MODULE 

☐ MODULE/PALLET 

☐ PALLET 

☐ ON-ORBIT CONTROL

☐ GROUND CONTROL

☐ CARRY-ON

DESIRED TIME ON-ORBIT 90(1) DAYS

NO. OF MISSIONS PER YEAR

CY	79	80	81	82	83	84	85	86	87	88	89	90	91
SORTIE						1	1	1	1	1	1	1	1

OPERATIONAL ORBIT, CHARACTERISTICS

	DESIRED	MINIMUM	MAXIMUM
ALTITUDE, APOGEE, km	ANY		
ALTITUDE, PERIGEE, km	ANY		
INCLINATION, deg	ANY		

MAJOR INSTRUMENTS/EQUIPMENT

NAME	DESCRIPTION	MEASUREMENT OBJECTIVE/FUNCTION
Separation Cover	Electrophoresis separation apparatus	Segregates 150-enzymes according to electrical surface charge properties
Control Console	Contains controls, monitors & displays	Controls electrophoretic separation column
Storage Container	Contain materials for processing	Provides protection for finished product and storage for waste materials

SPECIAL REQUIREMENTS/ASSUMPTIONS

REFERENCE DOCUMENTS

Discussions; MSFC, GE and MDAC personnel at MSFC, November 22, 1974

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SORTIE PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. SP-X3-S

PAYLOAD NAME SEPARATION OF ISO ENZYMES PAYLOAD MODEL CODE NO. NEW

✦ PHYSICAL CHARACTERISTICS OF P/L	WEIGHT, kg
✦ TOTAL P/L AT LAUNCH, kg	525
• PRESSURIZED EQUIP., kg	225
• UNPRESSURIZED EQUIP., kg	
• CONSUMABLES AT LAUNCH, kg	200
• EXPENDED CONSUMABLES & EQUIP. NOT RETURNED TO EARTH, kg	225(2)
• EST. PALLET LENGTH, m	–
• PRESSURIZED EQUIP. VOL, m^3	1.3

✦ ENVIRONMENTAL REQ'MTS IN-FLIGHT	OPERATING PRESS	OPERATING UNPRESS	NON-OPERATING PRESS	NON-OPERATING UNPRESS
• TEMP LIMIT, °K - MAX	ambient			
- MIN				
• HUMIDITY %				
• CLEANLINESS CLASS	UNK			
• ACOUSTIC LIMIT, dB OVERALL				
• ACCELERATION LIMIT, g	10^{-3}			
• RADIATION RATE LIMIT, J/kg-s				

REQUIREMENTS ON SHUTTLE/SPACELAB

✦ PAYLOAD PERSONNEL

- ESTIMATED NUMBER OF P/L PERSONNEL 1
- TOTAL P/L PERSONNEL TIME, hr/day 4
- TOTAL P/L PERSONNEL TIME, hr/mission 280 (1)
- P/L PERSONNEL OPERATION 1 SHIFT [XX] 2 SHIFTS [ ]
- NO. OF PLANNED EVA 0
- AVERAGE DURATION OF EVA, hr
- CONTINGENCY EVA YES [ ] NO [XX]

✦ PAYLOAD POWER – IN FLIGHT

	DC (W)	AC (W)
• AVERAGE POWER		270
• PEAK POWER		350
• ASCENT/DESCENT PWR		0

PEAK POWER DURATION, hr 280

TOTAL ENERGY, kWhr 590

AC FREQUENCY 60 Hz [XX] 400 Hz [ ] OTHER [ ]

✦ DATA/COMMUNICATIONS – ON ORBIT

- IS USE OF TDRS ASSUMED? YES [ ] NO [XX]
- VOICE – UP YES [ ] NO [XX] – DOWN YES [ ] NO [X]
- PHOTO FILM STORAGE WEIGHT, kg 0

	STORED	DOWN RT*	DOWN DUMP*	UP
• DIGITAL				
RATE (MAX), b/s	100	100		
DURATION, hr/opn		–		
hr/day		1		
TOTAL, Mb/day		NIL		
Mb/mission	NIL			
• ANALOG				
BANDWIDTH (MAX), MHz	0			
DURATION, hr/opn				
hr/day				
TOTAL DURATION, hr/msn				
• TV COLOR, hr/day	0			
BLACK & WHITE, hr/day	0			

✦ POINTING (SHUTTLE/SPACELAB).

- ACCURACY, arc sec NR
  - DURATION, hr/opn max
  - REPETITION RATE, opn/day
  - TOTAL POINTING TIME, hr/mission
- STABILITY, arc sec NR
  - DURATION, hr/opn max
- STABILITY RATE, arc sec/sec NR
- VIEWING CONSTRAINTS NR
- ORIENTATION NR

✦ SUPPORT/INTEG. EQUIP. REQ'D (NOT PROVIDED BY P/L)

- SPECIAL GIMBAL MOUNT/ POINTING PLATFORM? YES [ ] NO [XX]
  - TYPE EST. WEIGHT, kg

	QTY	TYPE/SIZE
• AIRLOCK		
• BOOM		
• VIEWPORT		
• OTHER		

✦ TIME CRITICAL ACCESS ON GROUND	TIME (HR)	DURATION (HR)	PURPOSE
• BEFORE LAUNCH	6	3	LOAD BIOLOGICALS
• AFTER LAUNCH	1	1	RETRIEVE BIOLOGICALS

✦ POTENTIAL HAZARDS (CHECK)

[ ] HIGH PRESSURE BOTTLES [ ] TOXIC GASES
[ ] PYROTECHNICS [ ] CRYOGENICS
[ ] OTHER

✦ COMMENTS (1) Active period - 70 days
(2) Electro apparatus can be left in orbit.

✦ COMPUTER SUPPORT REQ'D YES [ ] NO [XX]
- MAX WORD LENGTH BITS
- BULK MEMORY SIZE WORDS
- RAPID ACCESS MEMORY SIZE WORDS
- NO. OF COMPUTATIONS PER SECOND MAX
- COMPUTER FUNCTIONS:

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* RT = real time; DUMP = data dumped to ground within one day.

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SORTIE PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. SP-X4-S

PAYLOAD NAME SOLAR FURNACE FOR PRODUCTION OF SILICON RIBBON

DEVELOPMENT AGENCY NASA

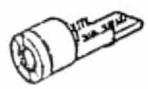
PREPARATION DATE Dec.11,1974 REVISION DATE 2-5-75 LTR A

PURPOSE PRODUCTION OF SEMICONDUCTOR SILICON IN RIBBON FORM

DISCIPLINE
☐ ASTRONOMY
☐ HIGH-ENERGY ASTROPHYSICS
☐ SOLAR PHYSICS
☐ ATMOSPHERIC & SPACE PHYSICS
☐ EARTH OBSERVATIONS
☐ EARTH & OCEAN PHYSICS
☒ SPACE PROCESSING
☐ LIFE SCIENCES
☐ SPACE TECHNOLOGY
☐ COMM/NAV.
☐ OTHER (SPECIFY)

PAYLOAD TYPE/MODE

☐ MODULE 

☐ MODULE/PALLET 

☒ PALLET 
- ☒ ON-ORBIT CONTROL
- ☐ GROUND CONTROL
- ☐ CARRY-ON

DESIRED TIME ON-ORBIT ____ DAYS

NO. OF MISSIONS PER YEAR

CY	79	80	81	82	83	84	85	86	87	88	89	90	91
SORTIE						1	1	1	1	1	1	1	1

OPERATIONAL ORBIT, CHARACTERISTICS

	DESIRED	MINIMUM	MAXIMUM
ALTITUDE, APOGEE, km	ANY		
ALTITUDE, PERIGEE, km	ANY		
INCLINATION, deg	ANY		

MAJOR INSTRUMENTS/EQUIPMENT

NAME	DESCRIPTION	MEASUREMENT OBJECTIVE/FUNCTION
Solar Furnace	Energy collector	
Processing Module	Ribbon shaping and storage device	

SPECIAL REQUIREMENTS/ASSUMPTIONS

REFERENCE DOCUMENTS

UNKNOWN Discussion - F. Shepphird/W. Marx, MDAC

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SORTIE PAYLOAD DATA SHEET

LEVEL A

PAYLOAD NO. SP-X4-S

PAYLOAD NAME SOLAR FURNACE FOR PRODUCTION OF SILICON RIBBON

PAYLOAD MODEL CODE NO. NEW

◆ PHYSICAL CHARACTERISTICS OF P/L	WEIGHT, kg
◆ TOTAL P/L AT LAUNCH, kg	1400
• PRESSURIZED EQUIP., kg	--
• UNPRESSURIZED EQUIP., kg	1200
• CONSUMABLES AT LAUNCH, kg	200
• EXPENDED CONSUMABLES & EQUIP. NOT RETURNED TO EARTH, kg	200 (1)
• EST. PALLET LENGTH, m	6
• PRESSURIZED EQUIP. VOL, m^3	

◆ ENVIRONMENTAL REQ'MTS IN-FLIGHT	MODE / LOCATION	OPERATING PRESS	OPERATING UNPRESS	NON-OPERATING PRESS	NON-OPERATING UNPRESS
• TEMP LIMIT, °K	MAX	UNK	UNK		
	MIN				
• HUMIDITY %		UNK			
• CLEANLINESS CLASS		UNK	UNK		
• ACOUSTIC LIMIT, dB OVERALL		UNK			
• ACCELERATION LIMIT, g		UNK			
• RADIATION RATE LIMIT, J/kg-s		UNK	UNK		

REQUIREMENTS ON SHUTTLE/SPACELAB

◆ PAYLOAD PERSONNEL

- ESTIMATED NUMBER OF P/L PERSONNEL 1
- TOTAL P/L PERSONNEL TIME, hr/day 2
- TOTAL P/L PERSONNEL TIME, hr/mission 150 (2)
- P/L PERSONNEL OPERATION 1 SHIFT [X] 2 SHIFTS [ ]
- NO. OF PLANNED EVA 1
- AVERAGE DURATION OF EVA, hr 5
- CONTINGENCY EVA YES [X] NO [ ]

◆ PAYLOAD POWER – IN FLIGHT

	DC (W)	AC (W)
• AVERAGE POWER	3500	
• PEAK POWER	3500	
• ASCENT/DESCENT PWR		0

PEAK POWER DURATION, hr 2160

TOTAL ENERGY, kWhr 7500

AC FREQUENCY 60 Hz [ ] 400 Hz [ ] OTHER [ ]

◆ DATA/COMMUNICATIONS – ON ORBIT

- IS USE OF TDRS ASSUMED? YES [ ] NO [X]
- VOICE – UP YES [ ] NO [X] – DOWN YES [ ] NO [X]
- PHOTO FILM STORAGE WEIGHT, kg

	STORED	DOWN RT*	DOWN DUMP*	UP
• DIGITAL				
RATE (MAX), b/s	100	100		
DURATION, hr/opn		--		
hr/day		1		
TOTAL, Mb/day		NIL		
Mb/mission	NIL			
• ANALOG				
BANDWIDTH (MAX), MHz	0			
DURATION, hr/opn				
hr/day				
TOTAL DURATION, hr/msn	0			
• TV COLOR, hr/day	0			
BLACK & WHITE, hr/day				

◆ POINTING (SHUTTLE/SPACELAB).

- ACCURACY, arc sec NR
  - DURATION, hr/opn max
  - REPETITION RATE, opn/day
  - TOTAL POINTING TIME, hr/mission
- STABILITY, arc sec NR
  - DURATION, hr/opn max
- STABILITY RATE, arc sec/sec NR
- VIEWING CONSTRAINTS NR
- ORIENTATION SOLAR INERTIAL

◆ SUPPORT/INTEG. EQUIP. REQ'D (NOT PROVIDED BY P/L)

- SPECIAL GIMBAL MOUNT/ POINTING PLATFORM? YES [ ] NO [X]

TYPE EST. WEIGHT, kg

	QTY	TYPE/SIZE
• AIRLOCK		
• BOOM		
• VIEWPORT		
• OTHER		

◆ TIME CRITICAL ACCESS ON GROUND	TIME (HR)	DURATION (HR)	PURPOSE
• BEFORE LAUNCH			
• AFTER LAUNCH			

◆ POTENTIAL HAZARDS (CHECK)

[ ] HIGH PRESSURE BOTTLES [ ] TOXIC GASES

[ ] PYROTECHNICS [ ] CRYOGENICS

[ ] OTHER

◆ COMMENTS (1) furnace can be left in orbit.
(2) active period

◆ COMPUTER SUPPORT REQ'D YES [ ] NO [X] • RAPID ACCESS MEMORY SIZE ______ WORDS

- MAX WORD LENGTH ______ BITS • NO. OF COMPUTATIONS PER SECOND ______ MAX
- BULK MEMORY SIZE ______ WORDS • COMPUTER FUNCTIONS:

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* RT = real time; DUMP = data dumped to ground within one day.

B. REQUIREMENTS DATA FOR NON-MOSC PAYLOADS

Tabular summaries of the 53 payloads included in the July 1974 SSPDA that were not considered for further analysis by the study team are herewith presented. This information is provided so that the applicable payload characteristics and requirements are available should a particular payload be included in a MOSC flight as a piggyback candidate. Complete information is not available on all payloads. Because these payloads are not primary MOSC candidates, the information has been presented only in English units.

GENERAL REQUIREMENTS

Sheets BI-1 and -2 contain the general mission requirements for each payload; identification of codes used on these sheets is as follows, reading the 18 columns from left to right:

1. Payload identification number and name per SSPDA, July 1974.

2. Identifies the type of sheets that are included in the July 1974 SSPDA. The Level A sheets are the two-page summaries of the payload characteristics and requirements, while the Level B sheets contain the more detailed information on the payload.

3. Identifies the number of SSPDA flights planned during the MOSC era.

4-7. These columns identify the type of payload. These types are module (M), pallet (P), module and pallet (M+P) and carry-on (C-O). It should be recognized that this identifies where major hardware items are located. Some payloads (i.e., AS-05-S) require a limited amount of controls in a pressurized area, such as at the Orbiter payload specialists station.

8. This column identifies the total number of manhours of orbital operations that are desired by the payload during the MOSC era.

9-17. These columns indicate apogee, perigee and inclination for each payload. The desired value is for optimum operation, the minimum and maximum values are those which can provide acceptable results.

GENERAL REQUIREMENTS (SHEET BI-1)

PAYLOAD		SSPDA SHEETS	FLIGHTS 1984+	PAYLOAD TYPE: MODULE	PAYLOAD TYPE: PALLET	PAYLOAD TYPE: MODULE/PALLET	PAYLOAD TYPE: CARRY ON	DESIRED TOTAL MANHOURS IN ORBIT	APOGEE (N. Mi): DESIRED	APOGEE (N. Mi): MIN	APOGEE (N. Mi): MAX	PERIGEE (N. Mi): DESIRED	PERIGEE (N. Mi): MAX	PERIGEE (N. Mi): MIN	INCLINATION (DEG): DESIRED	INCLINATION (DEG): MIN	INCLINATION (DEG): MAX	LAUNCH SITE
AS-05-S	— Very Wide Field Galactic Camera	AB	0		P			0	135	100	162	135	100	162	28.5	ANY	ANY	ETR/WTR
AS-06-S	— Calibration of Astronomical Fluxes	A	2		P			312	162	135	216	162	135	216	ANY	0	104	ETR/WTR
AS-07-S	— Cometary Simulation	A	2		P			204	162	108	270	162	108	270	28.5	0	104	ETR/WTR
AS-09-S	— 30m IR Interferometer	A	1		P			156	400	150	400	400	150	400	ANY	0	104	ETR/WTR
AS-11-S	— Polarimetric Experiments	A	1		P			78	135	100	162	135	100	162	ANY	0	104	ETR/WTR
AS-12-S	— Meteoroid Simulation	A	2		P			144	100	95	105	50	45	55	35	28	55	ETR
AS-14-S	— 1.0m Uncooled IR Telescope	A	0		P			0	216	100	340	216	100	340	ANY	28	104	ETR/WTR
AS-18-S	— 1.5 km IR Interferometer	A	4		P			864	216	100	270	216	100	270	30	0	90	ETR/WTR
AS-20-S	— 2.5m Cryogenically cooled IR Telescope	A	3		P			526	216	162	340	216	162	340	28.5	0	104	ETR/WTR
AS-41-S	— Schwartzschild Camera	A	0		P		C-O	0	216	108	340	216	108	340	ANY	0	57	ETR
AS-42-S	— FAR UV Electronographic Schmidt Camera/Spectrograph	A	0		P		C-O	0	216	108	340	216	108	340	ANY	0	57	ETR
AS-43-S	— UCB Black Brant Payload	A	1		P		C-O	5	ANY	86	340	ANY	86	340	ANY	ANY	ANY	ETR/WTR
AS-44-S	— XUV Concentrator/Detector	A	0		P		C-O	0	162	108	270	162	108	270	28.5	0	104	ETR/WTR
AS-45-S	— Proportional Counter Array	A	1		P		C-O	9	162	86	340	162	86	340	ANY	0	104	ETR/WTR
AS-46-S	— Wisconsin UV Photometry Experiment	A	0		P		C-O	0	108	86	216	108	86	216	0	0	104	ETR/WTR
AS-47-S	— Attached Far IR Spectrometer	A	0		P		C-O	0	189	108	ANY	189	108	ANY	28	0	104	ETR/WTR
AS-48-S	— Aries/Shuttle UV Telescope	A	0		P		C-O	0	135	81	340	135	81	340	ANY	0	104	ETR/WTR
AS-49-S	— First UCB Black Brant Payload	A	0		P		C-O	0	ANY	86	270	ANY	86	270	ANY	ANY	ANY	ETR/WTR
AS-50-S	— Combined UV/XUV Measurements (AS-04-S, 10-S)	A	3		P			468	248	135	259	248	135	259	28.5	0	104	ETR/WTR
AS-51-S	— Combined IR Payload (AS-01-S, 15-S)	A	2		P			312	216	162	270	216	162	270	28.5	0	104	ETR/WTR
AS-61-S	— Attached Far IR Photometer (Wide FOV)	A	0		P		C-O	0	189	135	ANY	189	135	ANY	28	0	104	ETR/WTR
AS-62-S	— Cosmic Background Anisotropy	A	7		P		C-O	0	189	108	216	189	108	216	28.5	0	104	ETR/WTR
HE-11-S	— X-ray Angular Structure	AB	4		P			268	120	108	128	120	108	128	28	28	30	ETR
HE-12-S	— High Inclination Cosmic Ray Survey	A	3		P			117	120	108	128	120	108	128	45	28.5	55	ETR
HE-13-S	— X-ray/Gamma Ray Pallet	A	4		P			208	120	108	128	120	108	125	28.5	28	30	ETR
HE-15-S	— Magnetic Spectrometer	AB	1		P			38	120	108	128	120	108	125	28.5	23	55	ETR
HE-16-S	— High Energy Gamma-Ray Survey	A	1		P			10	120	108	132	120	108	132	28.5	15	28.5	ETR

GENERAL REQUIREMENTS (SHEET BI-2)

PAYLOAD	SSPDA SHEETS	FLIGHTS 1984+	PAYLOAD TYPE: MODULE	PALLET	MODULE & PALLET	CARRY ON	DESIRED TOTAL MANHOURS IN ORBIT	APOGEE (N.Mi) DESIRED	MIN	MAX	PERIGEE (N.Mi) DESIRED	MIN	MAX	INCLINATION (DEG.) DESIRED	MIN	MAX	LAUNCH SITE
HE-17-S — High Energy Cosmic Ray Study	A	4		P			48	120	108	132	120	108	132	28.5	28	60	ETR
HE-18-S — Gamma-ray Photometric Studies	A	4		P			78	120	108	132	120	108	132	19	15	28.5	ETR
HE-20-S — High Resolution X-ray Telescope	A	1		P			78	120	108	132	120	108	132	22	15	28.5	ETR
HE-03-R — Extended X-ray Survey Revisit	A	1		P			96	200	190	210	200	190	210	28	26	30	ETR
SO-11-S — Solar Fine Pointing Payload	A B	1		P			206	203	189	216	203	189	216	56	56	90	ETR/WTR
SO-12-S — ATM Spacelab	A	0		P			0	232	216	248	232	216	248	28.5	28.5	57	ETR
SP-01-S — SPA No. 1 - Biological (Manned) (B+C)	A B	0			M+P		0	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR
SP-02-S — SPA No. 2 - Furnace (Manned) (F+C)	A	0			M+P		0	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR
SP-03-S — SPA No. 3 - Levitation (Manned) (L+C)	A	0			M+P		0	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR
SP-12-S — SPA No. 12 - Automated Furnace (FP+CP)	A	0		P			0	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR
SP-13-S — SPA No. 13 - Automated Levitation (LP+CP)	A	0		P			0	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR
SP-21-S — SPA No. 21 - Minimum Biological (B+C)	A	TBD	M				TBD	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR
SP-22-S — SPA No. 22 - Minimum Furnace (Manned) (F+C)	A	TBD	M				TBD	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR
SP-23-S — SPA No. 23 - Minimum General (G+C)	A	TBD	M				TBD	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR
SP-24-S — SPA No. 24 - Minimum Levitation (Manned) (L+C)	A	TBD	M				TBD	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR
ST-07-S — Neutral Beam Physics (Facil. No. 4)	A	4			M+P		100	VARIABLE	100	351	VARIABLE	100	351	28.5	0	90	ETR/WTR
ST-09-S — Controlled Contamination Release	A	0		P			0	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR
ST-11-S — Laser Information/Data Transmission	A	0			M+P		0	200	100	300	200	100	300	28.5	0	90	ETR/WTR
ST-12-S — Entry Technology	A	0				C-O	0	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR
ST-13-S — Wake Shield Investigation	A	4		P			40	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
CN-05-S — Laser Communication Experimentation	A B	4			M+P		77	150	100	256	150	100	256	50	30	90	ETR/WTR
CN-07-S — Large Reflector Deployment	A	4		P			94	150	100	250	150	100	250	55	0	104	ETR/WTR
CN-08-S — Open Traveling Wave Tube	A	3			M+P		45	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ANY	ETR/WTR
CN-11-S — Stars & Pads Experimentation	A	TBD			M+P		TBD	100	ANY	ANY	100	ANY	ANY	ANY	ANY	ANY	ETR/WTR
CN-12-S — Interferometric Navigation & Surveillance Techniques	A	3			M+P		56	200	150	250	200	150	250	55	0	90	ETR/WTR
CN-13-S — Shuttle Navigation Via Geosynchronous Satellite	A	3	M				63	200	150	250	200	150	250	55	0	90	ETR/WTR

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18. This column identifies the most acceptable launch sites due to inclination requirements. ETR is the Kennedy Space Center, WTR is the Vandenberg launch site.

WEIGHT, POWER, VOLUME, CREW AND HAZARDS DATA

Sheets BII-1 and -2 compile the weight, power, volume and crew requirements for each payload along with the potential hazards, in event of equipment failure, that could result in injury to personnel or cause damage to other equipment. Identification of the codes used on these sheets is as follows, reading the 24 columns from left to right:

1. Payload identification number per SSPDA, July 1974.

2. This is the launch weight for the payload for a 7-day flight. Includes equipment and consumables.

3. This is the payload weight after a 7-day flight.

4. This column indicates the weight of consumables for a 7-day flight.

5-6. These columns indicate the basic power requirements for each payload. The average power level is that required while operating on orbit. The peak power is the highest occasional short-duration peaks that occur during operation.

7. This column indicates the energy required for a 7-day flight.

8. This column indicates the pallet length required by the unpressurized equipment.

9. This column identifies the volume of payload equipment to be installed in a pressurized area, not including access space.

10. This column indicates the volume of pressurized area required to store the data recorded on orbit to be returned to Earth. The value is determined by applying volume factors to the various types of data requirements specified in the SSPDA.

WEIGHT, POWER, VOLUME, CREW, HAZARDS (SHEET BII-1)

PAYLOAD	7 DAYS LAUNCH WT (LBS)	7 DAYS DOWN WT (LBS)	7 DAYS CONSUMABLES (LBS)	POWER (W) AVERAGE	POWER (W) PEAK	7 DAYS ENERGY KWHR	PALLET LENGTH FT	PRESSURIZED VOLUME (FT³) PAYLOAD EQUIPMENT	PRESSURIZED VOLUME (FT³) DATA	PRESSURIZED VOLUME (FT³) OTHERS	PRESSURIZED VOLUME (FT³) TOTAL	UNPRESS VOLUME (FT³) PAYLOAD EQUIPMENT	UNPRESS VOLUME (FT³) OTHERS	UNPRESS VOLUME (FT³) TOTAL	CREW REQUIREMENTS CREW SIZE	CREW REQUIREMENTS 7 DAYS MANHOURS PER DAY	CREW REQUIREMENTS 7 DAYS TOTAL MANHOURS	POTENTIAL HAZARDS FROM PAYLOAD	POTENTIAL HAZARDS TO PAYLOAD
AS-05-S —	154	154	0	28	80	4.7	3.3	0.271	4.95	0	5.22	8.55	0	8.55	2	16	104		OPTICAL CONTAM EMI
AS-06-S —	4818	4270	548	500	500	78	13.5	30	12.5	0	42.5				2	16	104	HIGH PRESS	OPTICAL CONTAM
AS-07-S —	42,447	18,247	24,200	1137	1772	120	44.9	115.2	152						2	16	104	HIGH PRESS COLD TOUCH ? TOXIC GAS EMP CRYOGENS	OPTICAL CONTAM
AS-09-S —	5722	5678	44	1000	1500	144	54.5	60	75.9	0	135.9		0		2	16	104	HIGH PRESS	OPTICAL CONTAM
AS-11-S —	554	510	44	300	600	47	5	10.6	3.7	0	14.3		0		2	8	52	HIGH PRESS	OPTICAL CONTAM
AS-12-S —	5036	4860	176	1347	1882	81	20	11.2	5.7						1	8	52	HIGH PRESS	OPTICAL CONTAM
AS-14-S —	3399	3267	132	500	1000	78	9.8	32.8	6.9	0	39.7				1	8	52	CRYOGEN	OPTICAL CONTAM
AS-18-S —	12,901	12,681	220	1500	1775	131	29.9	45	68.4	0	113.4				2	16	104	HIGH PRESS CRYOGENS LASER HIGH VOLTAGE	OPTICAL CONTAM
AS-20-S —	9632	9220	1494	944	1262	148	15.1	32.8	6.9	0	39.7				2	16	104	CRYOGENS	OPTICAL CONTAM
AS-41-S —	356	334	22	80	100	12.48	9.2	0.71		0			0		1/2	1.5	10	HIGH PRESS	OPTICAL CONTAM
AS-42-S —	352	330	22	30	44	4.7	4.6	16.6	0.7	0	11.3		0		1/2	1.5	10	HIGH PRESS HIGH VOLTAGE	OPTICAL CONTAM
AS-43-S —	640	596	44	140	280	21.8	1.6	2.1	148	0	150.5		0		1	8	5	HIGH PRESS	OPTICAL CONTAM
AS-44-S —	293	240	53	150	200	23	3.3	2.3	3.2	0	5.5		0		1	1	8		
AS-45-S —	136	136	0	30	30	4.7	5.2	3.5	60	0	63.5		0		1/2	0.1	8	HIGH PRESS	
AS-46-S —	216	161	55	30	50	4.7	3.3	3.5	2.8	0	6.3		0		1/2	1.3	10	HIGH PRESS	OPTICAL CONTAM
AS-47-S —	374	308	66	10	30	1.6	3.3	2.1	6	0	8.1				1/2	0.8	5	CRYOGENS	OPTICAL CONTAM
AS-48-S —	1016	1016	0	250	300	39	9.8	10.6	297	0	308		0		1/2	1	8		OPTICAL CONTAM
AS-49-S —	601	557	44	140	280	0.28	16.4	2.1		0			0		1	2	2		
AS-50-S —	6536	5876	845	800	950	121	16.4	22	151	0	173		0		2	16	104	HIGH PRESS	OPTICAL CONTAM
AS-51-S —	20,209	19,373	1731	1444	1832	225	51.2	42.4	13.6				79.1		2	16	104	HIGH PRESS CRYOGENS	OPTICAL CONTAM
AS-61-S —	319	253	66	5	10	0.78	3.3	2.1	0.3						2	16	104	CRYOGENS	OPTICAL CONTAM
AS-62-S —	484	484	0	20	50	3.1	3.3	2.1	0.3	0	2.4		0		1/2	1.5	10		OPTICAL CONTAM
HE-11-S —	12,918	12,118	800	575	625	90	20	15	13			260	1.8	262	1	8	52	HIGH PRESS	OPTICAL CONTAM EMI
HE-12-S —	11,418	10,978	440	300	345	47	30.2	60	4.9						1	6	40	HIGH PRESS	
HE-13-S —	11,075	10,987	88	725	725	113	23	14.8	7.5						1	8	52	HIGH PRESS	
HE-15-S —	8807	8182	1536	160	234	27.8	15.1	15	3.5			624	14.5	639	2	16	104	HIGH PRESS CRYOGENS HIGH VOLTAGE	EMI
HE-16-S —	13,534	13,534	0	285	285	44.5	13.1	15	4	0	19		0		1	2	10	HIGH PRESS	

WEIGHT, POWER, VOLUME, CREW, HAZARDS (SHEET BII-2)

PAYLOAD	7 DAYS LAUNCH WT (LBS)	7 DAYS DOWN WT (LBS)	7 DAYS CONSUMABLES (LBS)	POWER (W) AVERAGE	POWER (W) PEAK	7 DAYS ENERGY KWHR	PALLET LENGTH FT	PRESSURIZED VOLUME (FT³) PAYLOAD EQUIPMENT	PRESSURIZED VOLUME (FT³) DATA	PRESSURIZED VOLUME (FT³) OTHERS	PRESSURIZED VOLUME (FT³) TOTAL	UNPRESS VOLUME (FT³) PAYLOAD EQUIPMENT	UNPRESS VOLUME (FT³) OTHERS	UNPRESS VOLUME (FT³) TOTAL	CREW REQUIREMENTS 7 DAYS CREW SIZE	CREW REQUIREMENTS 7 DAYS MANHOURS PER DAY	CREW REQUIREMENTS 7 DAYS TOTAL MANHOURS	POTENTIAL HAZARDS FROM PAYLOAD	POTENTIAL HAZARDS TO PAYLOAD
HE-17-S —	4400	4356	44	100	100	14.8	3.3	15	2.5									HIGH PRESS	
HE-18-S —	14,828	14,784	44	400	400	62.4	6.6	15	1.2									HIGH PRESS	
HE-20-S —	9537	9427	110	625	665	97.5	9.8	24.2	10.7						1	8	52	HIGH PRESS CRYOGENS	
HE-03-R —	9680	9251	440	1200	1400	115	13.1	10.6							1	2	24	HIGH PRESS	OPTICAL CONTAM
SO-11-S —	6950	6950	260	580	1060	58	28.9			0		706	0	706	4	37	208		OPTICAL CONTAM EMI
SO-12-S —	24,939	24,939	TBD	3200	3500	425	19.7	71		0			0		4	32	208		OPTICAL CONTAM EMI
SP-01-S —	5603	5526	557	TBD	TBD	9	4.3	173	.001						1	2	13	HIGH PRESS CRYOGENS LASER HIGH VOLTAGE BIOLOGICAL SAMPLES	MAGNETIC FIELD
SP-02-S —	7753	7610	986	TBD	TBD	0	8	97.2	.25						1/2	2	20	HIGH PRESS CRYOGENS HIGH TEMP	
SP-03-S —	9029	8886	986	TBD	TBD	0	8	133.5	1.8						1/2	3	22	HIGH PRESS CRYOGENS	
SP-12-S —	7011	6868	986	TBD	TBD	0	8	7.5	0.25						1	1	4	HIGH PRESS CRYOGENS HIGH TEMP	
SP-13-S —	8362	8219	986	TBD	TBD	0	8	7.5	1.8						1	1	3	HIGH PRESS CRYOGENS	
SP-21-S —	2037	2036	8.8	TBD	TBD	12.9	0	215.5	0.0007			0	0	0	1	2	2	HIGH PRESS HIGH VOLTAGE BIOLOGICAL SAMPLES LASER	MAGNETIC FIELD
SP-22-S —	1824	1824	0	TBD	TBD	16.4	0	156.1	0.07			0	0	0	1	2	2	HIGH PRESS HIGH VOLTAGE HIGH TEMP	
SP-23-S —	1646	1646	0	TBD	TBD	4.1	0	190.8	0.001			0	0	0	1	2	2	HIGH PRESS	
SP-24-S —	2046	2046	0	TBD	TBD	14.3	0	184.4	0.35			0	0	0	1	3	3	HIGH PRESS	
ST-07-S —	130	130	0	10	50	0.1	0	0	0.49	0	0.49		0						
ST-09-S —	139	125	11	149	182	3.6	2.3	0	1.06									HIGH PRESS	
ST-11-S —	119	119	0	160	360	1.4	16.4	14.8	38.9	0	53.7		0					HIGH VOLTAGE LASER	
ST-12-S —	8.8	8.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
ST-13-S —	990	990	0	TBD	TBD	TBD	16.4			0			0		1	1	10	BOOM RETRACTION	
CN-05-S —	856	856	114	624	1680	7.6	5.9	226.4	0.4	0	226.8	74.9	0	74.9	1/2	8	20	HIGH VOLTAGE LASER	OPTICAL CONTAM
CN-07-S —	4228	4228	222	691	1041	15.6	49	8.8		0			0		1	4	24	MECHANISM	
CN-08-S —	266	266	37	658	1067	5.9	1.6	5.7	0.14	0	5.84		0		1	3	15	HIGH VOLTAGE	
CN-11-S —	246	246	2.2	404	404	11.6	3.3	1.77	6.43	0	8.2		0		1	2	9		
CN-12-S —	416	416	17.6	203	431	3.8	1.6	9.2		0			0		1	4	19		
CN-13-S —	132	132	15.4	169	253	2	0	4.4	0.35	0	4.75	0	0	0	1	3	21		

11. The volumes for other consumables (contained in a pressurized area) are indicated in this column.

12. This column indicates the total volume required in a pressurized area.

13. This column identifies the volume of payload equipment to be installed in an unpressurized area.

14. The volume for consumables (contained in an unpressurized area) required to support the payload is included in this column.

15. This column indicates the total volume required in an unpressurized area.

16. The crew size for a 7-day flight is shown. A "1/2" in this column indicates that the payload requires only part-time support.

17,18. These columns indicate the number of manhours required per day and for a 7-day flight.

19-22. These columns identify potential hazards from the payload that, in the event of failure, could cause injury to people or damage to other equipment.

23-24. These columns identify potential hazards that could affect satisfactory operation of the payload.

ENVIRONMENT AND VIEWING REQUIREMENTS

Sheets BIII-1 and -2 compile the environmental and viewing requirements for each payload. Identification of the codes used on these sheets is as follows, reading the 24 columns from left to right:

1. Payload identification number per SSPDA, July 1974.

2,3. The cleanliness (class) requirements for the pressurized unpressurized equipment are identified in these columns.

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ENVIRONMENTAL AND VIEWING (SHEET BIII-1)

PAYLOAD	CLEANLINESS CLASS PRESS	CLEANLINESS CLASS UNPRESS	TEMPERATURE PRESSURIZED MAX	TEMPERATURE PRESSURIZED MIN	TEMPERATURE OR UNPRESSURIZED MAX	TEMPERATURE OR UNPRESSURIZED MIN	MAX HUMIDITY %	MAX ACOUSTIC LEVEL dB	MAXIMUM RADIATION RATE PRESS	MAXIMUM RADIATION RAD/HR UNPRESS	MAXIMUM RADIATION TOTAL RADS	VIEWING ORIENTATION	VIEWING CONSTRAINTS	POINTING ACCURACY SEC	POINTING STABILITY SEC	POINTING DURATION HR/OPN	POINTING STABILITY RATE	POINTING FIELD OF VIEW DEG	IS SPECIAL MOUNT REQ'D	ACCELERATION g
HE-17-S —	100K	100K	509	473	545	455	40	80		0.97		ANTI-EARTH	AXIS ±10° FROM ZENITH	3600	3600	1.5	NONE		NO	0.1
HE-18-S —	100K	100K	538	517	545	509	40	80		0.009		STELLAR ANTI-EARTH	>15° FROM EARTH	3600	360	1.5	0.5		NO	1E-03
HE-20-S —	100K	5K	538	517	545	509	40	60		0.97		STELLAR	>15° FROM EARTH >45° FROM SUN	30	1	1.5			NO	1E-04
HE-03-R —	100K	1K	536	518	527	491	40	80		0.97		BAY TOWARD TDRS	TDRS CONTACT WITH PAYLOAD	1800	1800	4	1		NO	1E-03
SO-11-S —	N/A	10K	536	518	526	524	25	70		10.85		SOLAR INERTIAL	VIEW SUN	1	0.5	0.85	0.0011	6	YES	1E-03
SO-12-S —	10K	10K	533	526	533	526	25	70	0.94	0.94		SOLAR INERTIAL	±48 MIN FROM SUN	360	360	0.9		30	NO	1E-03
SP-01-S —	100K	N/A	536	526	603	180	70	80	N/A	N/A	N/A	ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-02-S —	100K	N/A	536	526	603	180	70	80	N/A	N/A		ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-03-S —	100K	N/A	536	526	603	180	70	80	N/A	N/A		ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-12-S —	100K	N/A	536	526	603	180	70	80	N/A	N/A		ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-13-S —	100K	N/A	536	526	603	180	70	80	N/A	N/A		ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-21-S —	100K	N/A	536	526	N/A	N/A	70	80	N/A	N/A		ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-22-S —	100K	N/A	536	526	N/A	N/A	70	80	N/A	N/A		ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-23-S —	100K	N/A	536	526	N/A	N/A	70	80	N/A	N/A		ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
SP-24-S —	100K	N/A	536	526	N/A	N/A	70	80	N/A	N/A		ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-04
ST-07-S —	N/A	N/A	N/A	N/A	610	500	N/A	N/A				ANY	NONE	1800	3600	1.5	3600	NONE	NO	1E-04
ST-09-S —	N/A	N/A	N/A	N/A	610	500	N/A	N/A				ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	NONE
ST-11-S —	100K		560	500	610	500	95	60				EARTH AND OTHER SATELLITES	NONE	1800	360	0.25	360		NO	1E-02
ST-12-S —	N/A	N/A	N/A	N/A			N/A	N/A	N/A			ANY	NONE	NONE	NONE	NONE	NONE	NONE	NO	5
ST-13-S —		N/A										ANY	NONE	7200	3600	24			NO	1E-02
CN-05-S —	N/A	N/A	540	518	536	518	70	150	2870	52,500	500	EARTH GEOSYNCH SATELLITE	NONE	1800	360	0.5	36	160	NO	1E-02
CN-07-S —	100K	100K	540	500	563	500	70	150	2870	2870		EARTH STELLAR	NONE	1800	1800	1	180		NO	1E-03
CN-08-S —	100K	100K	540	500	563	500	70	150	2870	2870		EARTH AND SKY	NONE	NONE	NONE	NONE	NONE	NONE	NO	1E-02
CN-11-S —	100K	100K	540	518	536	518	70	120	2870	2870		CELESTIAL	UNOBSTRUCTED HEMISPHERE	3600	900	5.75	360		NO	1E-02
CN-12-S —	100K	100K	540	500	563	500	70	150	2870	2870		EARTH	NONE	1800	1500	0.25	180		NO	1E-03
CN-13-S —	100K	100K	540	500	563	500	70	150	2870	2870		ANY	ORBITER ANTENNA TO GROUND	NONE	NONE	NONE	NONE		NO	3.5

ENVIRONMENTAL AND VIEWING (SHEET BIII-2)

PAYLOAD	CLEANLINESS CLASS PRESS	CLEANLINESS CLASS UNPRESS	TEMPERATURE °R PRESSURIZED MAX	TEMPERATURE °R PRESSURIZED MIN	TEMPERATURE °R UNPRESSURIZED MAX	TEMPERATURE °R UNPRESSURIZED MIN	MAX HUMIDITY %	MAX ACOUSTIC LEVEL dB	MAXIMUM RADIATION RATE mRAD/HR PRESS	MAXIMUM RADIATION RATE mRAD/HR UNPRESS	MAXIMUM RADIATION TOTAL RADS	VIEWING ORIENTATION	VIEWING CONSTRAINTS	POINTING ACCURACY SEC	POINTING STABILITY SEC	POINTING DURATION HR/OPN	POINTING STABILITY RATE SEC/SEC	POINTING FIELD OF VIEW DEG	IS SPECIAL MOUNT REQ'D	ACCELERATION g
AS-05-S —	100K	1K	537	518	529	468	40	60	0.009	0.98	1.7E-03	STELLAR	>50° FROM EARTH, SUN MOON	1800	10	0.8	2	100	YES	1E-03
AS-06-S —	100K	1K	538	517	545	509	40	70		0.97		STELLAR	>15° FROM EARTH >45° FROM SUN	10	30	1.5	2.78E-04		NO	1E-03
AS-07-S —	100K	1K	536	518	563	491	40	70		0.97		TOWARD ARTIFICIAL COMET	>15° FROM EARTH	1800	1	0.083	NONE		YES	1E-03
AS-09-S —	100K	1K	538	517	563	491	40	70		0.97		STELLAR	>30° FROM EARTH, MOON >45° FROM SUN	1	0.02	1.55	0.0002		NO	1E-04
AS-11-S —	100K	1K	536	518	509	473	40	70		0.97		STELLAR	>20° FROM EARTH >90° FROM SUN	2	2	1			YES	1E-03
AS-12-S —	100K	5K	536	518	563	491	40	80		0.97		TOWARD REENTRY SAMPLES	DARK BACKGROUND	30	10	0.083			YES	1.0
AS-14-S —	100K	1K	537	518	522	486	40	80		0.97		STELLAR	>15° FROM EARTH >45° FROM SUN	10	1	1	0.2		YES	1E-03
AS-18-S —	100K	1K	536	518	545	473	40	70		0.97		STELLAR	>30° FROM EARTH >45° FROM SUN	1	1	1			YES	1E-04
AS-20-S —	100K	1K	537	518	522	486	40	60		0.97		STELLAR	>30° FROM EARTH >45° FROM SUN	10	1	1	0.1		YES	1E-03
AS-41-S —	100K	5K	537	518	558	450	40	70		0.009		STELLAR	>15° FROM EARTH >90° FROM SUN	360	1	0.7			YES	1E-03
AS-42-S —	100K	5K	537	518	558	486	40	70		0.009		STELLAR	>15° FROM EARTH >45° FROM SUN	3600	10	1.55			YES	1E-03
AS-43-S —	100K	5K	536	518	576	504	40	80		0.97		STELLAR	>15° FROM EARTH >45° FROM SUN	60	2	1.5	1		YES	1E-02
AS-44-S —	100K	5K	537	518	630	450	40	60	3.85	0.97		STELLAR	>15° FROM EARTH >30° FROM SUN	100	30	1.5			YES	1
AS-45-S —	100K	10K	533	522	545	491	40	80		0.98		STELLAR	>15° FROM SUN	360	360	1.5			NO	0.1
AS-46-S —	100K	10K	538	517	563	491	40	80		0.97		STELLAR	>15° FROM EARTH >90° FROM SUN	60	1	0.5	1		YES	1E-03
AS-47-S —	100K	100	538	517	576	468	40	70		0.97		STELLAR	>30° FROM EARTH >45° FROM SUN	1800	1800	1.5	NONE		YES	0.1
AS-48-S —	100K	5K	537	518	630	450	40	60	3.85	0.97		STELLAR	>5° FROM MOON >30° FROM SUN	1	1	1.55			NO	1
AS-49-S —	100K	5K	536	518	576	504	40	80		0.97		STELLAR	>15° FROM EARTH >45° FROM SUN	1800	1800	1.5	20		NO	1E-02
AS-50-S —	100K	1K	536	518	527	508	40	60		0.97		STELLAR	>15° FROM EARTH >45° FROM SUN	1	1	1.5			YES	1E-04
AS-51-S —	100K	1K	537	518	522	486	40	60	3.85	0.97		STELLAR	>30° FROM EARTH >70° FROM SUN	5	1	1			YES	1E-03
AS-61-S —	100K	100	538	516	576	468	40	70		0.97		STELLAR	>30° FROM EARTH >45° FROM SUN	3600	1800	1.5	NONE		NO	0.1
AS-62-S —	100K	100	538	516	576	468	40	70		0.97		STELLAR	>30° FROM EARTH >45° FROM SUN	3600	1800	1.5	NONE		NO	0.1
HE-11-S —	100K	10K	531	524	497	479	40	60	0.98	0.98	0.168	STELLAR	>15° FROM EARTH	360	1	1.5		60	YES	1E-02
HE-12-S —	100K	100K	536	518	527	491	40	80		0.97		ANTI-EARTH	WITHIN 0.5° OF ZENITH	1800	1800	1.5	NONE		NO	0.1
HE-13-S —	100K	100K	536	518	527	491	40	80		0.97		STELLAR	>15° FROM EARTH	360	360	1.5	NONE		NO	1E-03
HE-15-S —	100K	100K	537	517	661	358	40	60	4.02	4.02	0.168	ANTI-EARTH	>20° FROM EARTH	1800	1800	1.5	NONE	60	NO	1E-03
HE-16-S —	100K	100K	538	517	661	376	50	80		0.98		STELLAR	ANTI-EARTH	360	360	1.5	1		YES	1E-04

4-7. The maximum and minimum temperatures for the payload pressurized and unpressurized equipment is provided in these columns. These temperatures are at the payload-Spacelab/Orbiter interface.

8. This column identifies the maximum allowable relative humidity.

9. This column indicates the allowable overall acoustic levels (0 db = 20 N/m^2).

10-12. These columns indicate the maximum allowable radiation rates and total allowable radiation that the payload equipment can tolerate. The use of "E" refers to exponent (i.e., 1E-03 is 1×10^{-3}).

13. Intentionally blank.

14-17. These columns identify specific viewing orientation requirements and any special constraints that should be satisfied for payload operation.

18. Pointing accuracy required of the gimbal mount/platform is indicated in this column.

19. This column indicates the pointing stability required of the gimbal mount/platform.

20. The maximum duration in hours per operation that the pointing system must maintain the required values is identified in this column.

21. This column identifies the maximum allowable angular velocity, or jitter rate, of the payload line of sight.

22. This column indicates the field of view of the payload equipment (such as an antenna, telescope, or detector).

23. A "yes" in this column indicates that a special gimbal mount or pointing platform is required in order to obtain satisfactory data. A "no" indicates that the basic Spacelab/Orbiter pointing accuracies are acceptable.

24. This column identifies the translational acceleration limits of each payload, while operating. The use of "E" refers to exponent (i.e., 1E-03 is 1×10^{-3}).

C. REQUIREMENTS SUMMARY FOR MOSC PAYLOAD COMBINATIONS

Tabular summaries of the 19 payload combinations to be considered further by the study team are presented here.

Sheets CI-1 through -3 contain the most significant characteristics for these combinations. Other characteristics can be determined by referring to the individual payload summaries. Identification of the codes used on these sheets is as follows, reading the 25 columns from left to right:

1. Identifies MOSC payload combination by number.

2. This column identifies the payload combinations. The types of payloads are indicated and the individual payloads in the combination are listed by number per SSPDA, July 1974.

3. This column indicates the desired total numbers of orbital manhours that are desired for the combinations. These are determined by addition of the manhours of the individual payloads as specified in the SSPDA. Where a payload is included in more than one combination, the individual manhours are split among the combinations to provide sufficient time in each combination for gathering data.

4. This column identifies the crew size required to support the combinations.

5-8. These columns indicate the launch weight for the combinations for 7-, 30-, 60-, and 90-day flights. These values are obtained by addition of the individual payload weights. The first value in the columns, for each combination, is in English units and the second value is in the International System of units.

MOSC PAYLOAD COMBINATIONS (SHEET CI-1)

PAYLOAD COMBINATION IDENTIFICATION		DESIRED TOTAL ORBITAL TIME	CREW SIZE	LAUNCH WEIGHT				PRESSURIZED VOLUME					UNPRESSURIZED VOLUME					ENERGY					POWER	
				7 DAYS	30 DAYS	60 DAYS	90 DAYS	EQUIPMENT	TOTAL COMBINATION 7 DAYS	30 DAYS	60 DAYS	90 DAYS	EQUIPMENT	TOTAL COMBINATION 7 DAYS	30 DAYS	60 DAYS	90 DAYS	7 DAYS	30 DAYS	60 DAYS	90 DAYS		AVE.	PEAK
COMB	PAYLOADS	MANHOURS	No.	LBS	LBS	LBS	LBS	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	KwHr	KwHr	KwHr	KwHr		WATTS	KW
				Kg	Kg	Kg	Kg	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3							
C01	IR TELESCOPES	2168	3	19,012	27,461	38,499	49,851	62.8	63.9	68.5	74.8	81.2	3989	4060	4483	5013	5542	296	1658	3434	5210		50	1
	(AS-01-S, AS-15-S)			8622	12,454	17,460	22,608	1.78	1.81	1.94	2.12	2.3	113	115	127	142	157							
C02	UV TELESCOPES	6627	4	14,541	18,112	[illegible]742	27,521	53.7	58.6	81.5	111.2	140.5	978	978	978	978	978	306	1716	3554	5392		51	1
	(AS-03-S, AS-04-S,			6595	8214	10,314	12,481	1.52	1.66	2.31	3.15	3.98	27.7	27.7	27.7	27.7	27.7							
	AS-08-S, AS-10-S)																							
C03	SOLAR OBSERVATIONS	6248	4	12,582	14,485	17,159	19,863	98.1	101	113.7	130	146.8	904	904	904	904	904	63.3	356	736	1116		11	1
	(AS-13-S, SO-01-S)			5706	6569	7782	9008	2.78	2.86	3.22	3.68	4.16	25.6	25.6	25.6									
C04	AMPS, COMM/NAV #1	3000	5	16,178	17,263	18,641	20,229	712	718	745	777	812	1977	1980	1987	1998	2005	520	2912	6032	9152		87	2
	(AP-06-S, CN-02-S)			7337	7829	8454	9174	20.17	20.33	21.1	22	23	56	56.1	56.3	56.6	56.8							
C05	AMPS, COMM/NAV #2	2400	4	13,927	15,102	16,504	18,143	194.2	202.6	237.9	283.8	330.1	1963	1966	1973	1984	1991	431	2411	4994	7578		72	2
	(AP-06-S, CN-04-S,			6316	6849	7485	8228	5.5	5.74	6.74	8.04	9.35	55.6	55.7	55.9	56.2	56.4							
	CN-06-S)																							
C06	AMPS, EARTH OBSERV	4793	4	15,991	19,441	23,964	28,687	224.9	234.7	277.8	333.6	391.1	1624	1624	1631	1641	1649	623	3488	7226	10,964		105	2
	OCEAN PHYS (AP-06-S,			7252	8817	10,868	13,010	6.37	6.65	7.87	9.45	11.08	46	46	46.2	46.5	46.7							
	EO-07-S, OP-05-S)																							
C07	SPACE PROCESSING,	1322	4	16,460	22,992	33,406	43,397	379.8	398.9	487	600	713	216	675	[illegible]27	5554	8331	1162	6507	13,479	20,451		195	10
	SPACE TECH (SP-14-S,			7465	10,427	15,150	19,681	10.76	11.3	13.8	17	20.2	6.12	19.12	80.1	155.2	236							
	ST-04-S, ST-05-S)																							

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MOSC PAYLOAD COMBINATIONS (SHEET CI-2)

PAYLOAD COMBINATION IDENTIFICATION		DESIRED TOTAL ORBITAL TIME	CREW SIZE	LAUNCH WEIGHT				PRESSURIZED VOLUME					UNPRESSURIZED VOLUME					ENERGY					POWER	
				7 DAYS	30 DAYS	60 DAYS	90 DAYS	EQUIPMENT	TOTAL COMBINATION 7 DAYS	30 DAYS	60 DAYS	90 DAYS	EQUIPMENT	TOTAL COMBINATION 7 DAYS	30 DAYS	60 DAYS	90 DAYS	7 DAYS	30 DAYS	60 DAYS	90 DAYS		AVE.	PEAK
COMBO	PAYLOADS	MANHOURS	No.	LBS	LBS	LBS	LBS	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	KwHR	KwHR	KwHR	KwHR		WATTS	KW
				Kg	Kg	Kg	Kg	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3							
C08	0-G CLOUD PHYSICS,	1403	3	9830	12,595	16,326	20,328	667	674	699	731	762	1359	1359	1359	1359	1359	204	1144	2370	3595		34	1
	SPACE TECH (EO-01-S,			4458	5703	7404	9219	18.9	19.1	19.8	20.7	21.6	38.5	38.5	38.5	38.5	38.5							
	ST-21-S, ST-22-S)																							
C09	EARTH OBSERV, OCEAN	1113	3	19,871	25,884	33,734	41,829	116.1	127.1	179.6	239.3	303.6	6043	6043	6043	6043	6043	479	2683	5557	8431		80	2
	PHYSICS #1 (EO-05-S,			9012	11,739	15,299	18,970	3.29	3.6	5.09	6.78	8.66	171.2	171.2	171.2	171.2	171.2							
	OP-02-S, OP-06-S)																							
C10	EARTH OBSERV, OCEAN	1027	3	18,533	23,450	29,820	36,418	24	25.4	32.8	42	52.2	5973	5973	5973	5973	5973	288	1613	3341	5069		48	2
	PHYSICS #2 (EO-05-S,			8405	10,635	13,524	16,516	0.68	0.72	0.93	1.19	1.48	169.2	169.2	169.2	169.2	169.2							
	EO-06-S, OP-03-S,																							
	OP-04-S)																							
C11	HIGH ENERGY ASTROPHY,	1879	3	17,913	19,790	22,008	24,548	169.8	171.9	181.4	195.9	209.3	1017	1017	1017	1017	1017	181	1014	2099	3185		30	1
	SPACE TECHNOLOGY			8124	8975	9981	11,133	4.81	4.87	5.14	5.55	5.93	28.8	28.8	28.8	28.8	28.8							
	(AS-19-S, HE-14-S,																							
	HE-19-S, ST-06-S)																							
C12	LIFE SCIENCE, SPACE	795	4	34,477	50,038	70,847	92,533	1163	1172	1211	1228	1310	0	773	3848	8013	12,143	2158	12,082	25,027	37,972		362	10
	PROCESS #1 (LS-09-S,	(SP ONLY)		15,636	22,693	32,130	41,965	32.95	33.2	34.3	34.8	37.1	0	21.9	109	227	344							
	LS-10-S, SP-04-S,																							
	SP-05-S, SP-16-S)																							

MOSC PAYLOAD COMBINATIONS (SHEET CI-3)

PAYLOAD COMBINATION IDENTIFICATION		DESIRED TOTAL ORBITAL TIME	CREW SIZE	LAUNCH WEIGHT				PRESSURIZED VOLUME					UNPRESSURIZED VOLUME					ENERGY					POWER	
								EQUIPMENT	TOTAL COMBINATION				EQUIPMENT	TOTAL COMBINATION										
				7 DAYS	30 DAYS	60 DAYS	90 DAYS		7 DAYS	30 DAYS	60 DAYS	90 DAYS		7 DAYS	30 DAYS	60 DAYS	90 DAYS	7 DAYS	30 DAYS	60 DAYS	90 DAYS		AVE	PEAK
COMBO	PAYLOADS	MANHOURS	NO.	LBS	LBS	LBS	LBS	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	FT^3	KwHR	KwHR	KwHR	KwHR		WATTS	KW
				Kg	Kg	Kg	Kg	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3							
C13	LIFE SCIENCE,	234	4	30,356	42,801	59,028	75,938	1116	1126	1164	1214	1264	719	1215	3530	6531	9496	2238	12,530	[illegible]	[illegible]		376	6
	SPACE PROCESSING #2	(SP ONLY)		13,767	19,411	26,770	34,439	31.62	31.87	32.97	34.39	35.8	20.37	34.43	[illegible]	185	269							
	(LS-09-S, LS-10-S,																							
	SP-15-S, SP-19-S)																							
C14	COMBINED IR AND UV	2340	2	17,620	29,529	45,131	61,088	56.2	56.2	56.2	56.2	56.2	1667	[illegible]	[illegible]	2271	2572	371	2078	4304	6530		62	2
	TELESCOPES (AS-31-S)			8009	13,422	20,514	27,767	1.59	1.59	1.59	1.59	1.59	47.2	[illegible]	55.75	64.27	72.83							
C15	COMBINED UV	780	2	15,737	25,500	38,688	52,185	28.8	28.8	28.8	[illegible]	[illegible]	[illegible]	944	944	944	944	201	1126	2332	3538		34	1
	TELESCOPES (AS-54-S)			7017	11,591	17,586	23,721	0.82	0.82	0.82	[illegible]	[illegible]	26.72	26.72	26.72	26.72	26.72							
C16	LARGE HIGH ENERGY	LONG TERM	2	34,320	36,047	43,339	50,349	5650	5650	5650	5650	5650	–	–	–	–	–	120	672	1392	2112		20	[illegible]
	ASTROPHY (HE-X-S)			15,600	17,294	19,700	22,886	160	160	160	160	160	–	–	–	–	–							
C17	LONG TERM LIFE	LONG TERM	4	20,999	25,462	31,660	38,280	1589	1589	1589	1589	[illegible]	–	–	–	–	–	1346	7538	15,614	23,690		226	8
	SCIENCE (LS-X-S)			9545	11,574	14,391	17,400	45	45	45	45	45	–	–	–	–	–							
C18	LARGE SPACE	782	2	7102	7386	7823	8523	142	142	142	142	142	1418	1418	1418	1418	1418	242	1355	2807	4259		41	2
	TECHNOLOGY (ST-23-S)			3228	3359	3583	3874	4.02	4.02	4.02	4.02	[illegible]	[illegible]	40.16	40.16	40.16	40.16							
C19	PRODUCTION PROCESS	940	1	6494	6494	6494	6494	141.2	141.2	141.2	141.2	141.2	60	60	60	60	60	181	1011	2094	3177		30	5
	FACILITY (SP-X5-S)			2945	2945	2945	2945	4	4	4	4	4	1.7	1.7	1.7	1.7	1.7							

9. This column contains the pressurized equipment volume for each combination. The values in the English and International System of Units are as in Columns 5-8.

10-13. These columns contain the pressurized volume for the total combination. This value is based on a retention of 0.05 percent of the data indicated in the SSPDA. The values in the English and International System of Units are as in Columns 5-8.

14. This column contains the unpressurized equipment volume for each combination. The values in the English and International System of Units are as in Columns 5-8.

15-18. These columns contain the unpressurized equipment volume for the total combination. The values in the English and International System of Units are as in Columns 5-8.

19-22. These columns indicate the energy requirements for the combinations for 7-, 30-, 60-, and 90-day flights.

23-25. Intentionally blank.

The combination C-19, Space Manufacturing, is described by the preliminary SSPDA Level A data sheets.

SORTIE PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. SP-X5-S

PAYLOAD NAME SPACE PRODUCTION FACILITY PAYLOAD MODEL CODE NO. B

+ PHYSICAL CHARACTERISTICS OF P/L	WEIGHT, kg
+ TOTAL P/L AT LAUNCH, kg	3,200
• PRESSURIZED EQUIP., kg	1,800
• UNPRESSURIZED EQUIP., kg	1,400
• CONSUMABLES AT LAUNCH, kg	500
• EXPENDED CONSUMABLES & EQUIP. NOT RETURNED TO EARTH, kg	(1) 500
• EST. PALLET LENGTH, m	6
• PRESSURIZED EQUIP. VOL, m^3	4

+ ENVIRONMENTAL REQ'MTS IN-FLIGHT	OPERATING PRESS	OPERATING UNPRESS	NON-OPERATING PRESS	NON-OPERATING UNPRESS
• TEMP LIMIT, °K - MAX				
- MIN				
• HUMIDITY %				
• CLEANLINESS CLASS				
• ACOUSTIC LIMIT, dB OVERALL				
• ACCELERATION LIMIT, g	10^{-4}			
• RADIATION RATE LIMIT, J/kg-s				

REQUIREMENTS ON SHUTTLE/SPACELAB

+ PAYLOAD PERSONNEL
- ESTIMATED NUMBER OF P/L PERSONNEL 2
- TOTAL P/L PERSONNEL TIME, hr/day TBD
- TOTAL P/L PERSONNEL TIME, hr/mission (2) 1,100
- P/L PERSONNEL OPERATION 1 SHIFT [XX] 2 SHIFTS [ ]
- NO. OF PLANNED EVA 1
- AVERAGE DURATION OF EVA, hr 5
- CONTINGENCY EVA YES [X] NO [ ]

+ PAYLOAD POWER – IN FLIGHT

	DC (W)	AC (W)
• AVERAGE POWER	5000	—
• PEAK POWER	7000	
• ASCENT/DESCENT PWR		

PEAK POWER DURATION, hr TBD
TOTAL ENERGY, kWhr 20,000
AC FREQUENCY 60 Hz [X] 400 Hz [ ] OTHER [ ]

+ DATA/COMMUNICATIONS – ON ORBIT
- IS USE OF TDRS ASSUMED? YES [ ] NO [XX]
- VOICE – UP YES [ ] NO [XX] – DOWN YES [ ] NO [X]
- PHOTO FILM STORAGE WEIGHT, kg –

	STORED	DOWN RT*	DOWN DUMP*	UP
• DIGITAL				
RATE (MAX), b/s				
DURATION, hr/opn				
hr/day				
TOTAL, Mb/day				
Mb/mission				
• ANALOG				
BANDWIDTH (MAX), MHz				
DURATION, hr/opn				
hr/day				
TOTAL DURATION, hr/msn				
• TV COLOR, hr/day				
BLACK & WHITE, hr/day				

+ POINTING (SHUTTLE/SPACELAB).
- ACCURACY, arc sec
  - DURATION, hr/opn max
  - REPETITION RATE, opn/day
  - TOTAL POINTING TIME, hr/mission
- STABILITY, arc sec
  - DURATION, hr/opn max
- STABILITY RATE, arc sec/sec
- VIEWING CONSTRAINTS
- ORIENTATION SOLAR INERTIAL

+ SUPPORT/INTEG. EQUIP. REQ'D (NOT PROVIDED BY P/L)
- SPECIAL GIMBAL MOUNT/ POINTING PLATFORM? YES [ ] NO [ ]
  TYPE EST. WEIGHT, kg

	QTY	TYPE/SIZE
• AIRLOCK		
• BOOM		
• VIEWPORT		
• OTHER		

+ TIME CRITICAL ACCESS ON GROUND	TIME (HR)	DURATION (HR)	PURPOSE
• BEFORE LAUNCH			
• AFTER LAUNCH			

+ POTENTIAL HAZARDS (CHECK)
[ ] HIGH PRESSURE BOTTLES [ ] TOXIC GASES
[ ] PYROTECHNICS [ ] CRYOGENICS
[ ] OTHER

+ COMMENTS (1) Facility equipment can be left in orbit.
(2) Active period.
(3) Total Mission 10 Years

+ COMPUTER SUPPORT REQ'D YES [ ] NO [ ]
- MAX WORD LENGTH ______ BITS
- BULK MEMORY SIZE ______ WORDS
- RAPID ACCESS MEMORY SIZE ______ WORDS
- NO. OF COMPUTATIONS PER SECOND ______ MAX
- COMPUTER FUNCTIONS:

SSPD(LA-2) 4/74

* RT = real time; DUMP = data dumped to ground within one day.

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SORTIE PAYLOAD DATA SHEET
LEVEL A

PAYLOAD NO. SP-X5-S

PAYLOAD NAME SPACE PRODUCTION FACILITY

DEVELOPMENT AGENCY NASA

PREPARATION DATE Dec.11,1974 REVISION DATE 8-5-75 LTR B

PURPOSE MANUFACTURE PRODUCTS IN SPACE

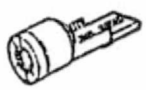
DISCIPLINE

- [ ] ASTRONOMY
- [ ] HIGH-ENERGY ASTROPHYSICS
- [ ] SOLAR PHYSICS
- [ ] ATMOSPHERIC & SPACE PHYSICS
- [ ] EARTH OBSERVATIONS
- [ ] EARTH & OCEAN PHYSICS
- [x] SPACE PROCESSING
- [ ] LIFE SCIENCES
- [ ] SPACE TECHNOLOGY
- [ ] COMM/NAV.
- [ ] OTHER (SPECIFY)

PAYLOAD TYPE/MODE

- [ ] MODULE

- [x] MODULE/PALLET



- [ ] PALLET

- [ ] ON-ORBIT CONTROL
- [ ] GROUND CONTROL
- [ ] CARRY-ON

DESIRED TIME ON-ORBIT 90(3) DAYS

NO. OF MISSIONS PER YEAR (3)

CY	79	80	81	82	83	84	85	86	87	88	89	90	91
SORTIE												1	1

OPERATIONAL ORBIT, CHARACTERISTICS

	DESIRED	MINIMUM	MAXIMUM
ALTITUDE, APOGEE, km	ANY		
ALTITUDE, PERIGEE, km	ANY		
INCLINATION, deg	ANY		

MAJOR INSTRUMENTS/EQUIPMENT

NAME	DESCRIPTION	MEASUREMENT OBJECTIVE/FUNCTION
Engraver/ Microscope	SP-X1-S	
Furnace	SP-X2-S	
Separation Col.	SP-X3-S	
Solar Furnace	SP-X4-S	
Control Console		

SPECIAL REQUIREMENTS/ASSUMPTIONS

Discussions with MSFC, MDAC and GE personnel, November 22, 1974

REFERENCE DOCUMENTS

Appendix B
SKYLAB II CREW ACTIVITIES ANALYSIS

In order to establish guidelines for the allocation of crew time during an extended duration flight, the "as-flown" Skylab Flight Plan was examined. The daily time allocations for each of the three crewmen provided an empirical data base from which allocation factors could be analytically derived. As a first step in this analysis, each of the 60 days of the second mission was examined and the time spent by each crewman summarized. The individual activity times extracted from the "as-flown" timeline are the 15 listed in Table B-1. The data extracted, and converted to a computerized file scheme, are shown in Table B-2. In this table the first column represents the mission day, the leading digit 1 representing Commander Bean, the leading digit 2 representing Science Pilot Garriott, and the leading digit 3 representing Pilot Lousma. The next 15 columns, as shown in Table B-2 and as separated by commas, correspond on a one-to-one basis to the activities listed in Table B-1.

Table B-1
SKYLAB CREW ACTIVITIES

1. Sleep
2. Eating (includes food preparation), pre- and postsleep periods
3. Apollo telescope mount operation
4. Earth resources package operation
5. Corollary experiments operation
6. Medical experiments operation
7. Maintenance and operations
8. Personal hygiene
9. Personal training
10. Housekeeping and equipment transfer
11. Rest and relaxation
12. Student experiments and TV operation
13. Extravehicular activities (EVA)
14. Launch and recovery operations
15. Station activation/deactivation

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Table B-2

SKYLAB II CREW ACTIVITIES

UNITS SHOWN ARE ACTIVITY DURATION IN HOURS

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101-8,2.9,0,0,0,0,0,0,0,0,0,0,0,9.1,4
102-8,4,0,0,0,0,0,0,0,0,2,0,0,0,10
103-9.5,5.4,0,0,0,0,4.3,.3,0,1.5,0,0,0,0,3
104-8,6.5,0,0,0,0,0,.2,.8,3,4.8,0,0,0,.7
105-8,6,0,1,1.5,2.2,2.6,.3,0,2.4,0,0,0,0,0
106-8,6.2,0,.5,4.1,0,0,.6,.5,3.1,1,0,0,0,0
107-8,6.1,0,3.6,4.5,0,0,.5,1.3,0,0,0,0,0,0
108-8,5.6,0,2.5,1.5,2.2,0,.5,1,2.7,0,0,0,0,0
109-8,5.9,0,4.2,0,0,0,.3,.6,0,0,0,5,0,0
110-7.2,4.8,0,0,0,0,0,0,0,0,0,0,12,0,0
111-8.5,7.7,0,0,0,4.9,0,.7,0,1.7,0,0,.5,0,0
112-8,6.7,2.2,2.6,1.6,0,.7,.3,1,.9,0,0,0,0,0
113-8,4.9,0,3.5,.7,1,1.5,.5,1,2.9,0,0,0,0,0
114-8,7.6,1.2,0,0,0,1.1,.3,1,4.8,0,0,0,0,0
115-7,7.5,1.2,5.6,.4,0,0,.5,1,.8,0,0,0,0,0
116-8.7,3.2,2.8,4.6,1.7,1.7,0,.3,1,0,0,0,0,0,0
117-8,7.1,.9,.6,4.2,2.2,0,.5,.5,0,0,0,0,0,0
118-8,6.9,6.9,.4,.3,0,0,.5,1,0,0,0,0,0,0
119-8,5.5,3.7,.5,4.3,0,0,.5,1,.5,0,0,0,0,0
120-8,4.6,2.2,0,4.6,2.4,0,.3,.5,1.4,0,0,0,0,0
121-8,3.7,1.2,0,7.3,1.2,0,.6,1,0,0,1,0,0,0
122-8.6,6.2,4.6,0,.3,0,.5,0,0,1.8,2,0,0,0,0
123-8,4.7,3,0,4.7,0,0,.6,1,2,0,0,0,0,0
124-8,3,2.2,0,.3,1.8,8.3,.4,0,0,0,0,0,0,0
125-8,5.4,2.5,0,4.6,2.2,0,.3,1,0,0,0,0,0,0
126-8,2.5,5,0,1,1.8,3.3,.5,1,0,0,.9,0,0,0
127-8.5,3.4,2.8,0,1.1,0,2.2,.3,1,2.5,0,0,2.2,0,0
128-8,3.5,1.2,0,0,0,.8,0,0,0,0,0,10.5,0,0
129-8,4.8,3.4,0,2.1,1.6,0,.3,1,2.1,.5,.2,0,0,0
130-9.7,4.4,2.3,0,2.5,0,0,.3,1,3.8,0,0,0,0,0
131-7.8,2.9,3.8,0,5.9,1.6,0,.3,1,.7,0,0,0,0,0
132-8,3.4,5.2,0,2.3,2.2,0,.3,.8,.6,0,1.2,0,0,0
133-8,2.9,3.4,0,.7,0,0,.6,1,.3,0,.8,0,0,0
134-8,3.4,0,0,6.7,3,1,.3,.6,1,0,0,0,0,0
135-8,2.6,2.2,0,4,3.5,1.8,.9,1,0,0,0,0,0,0
136-8,3.3,1.3,3.3,3,2.6,0,0,0,2.5,0,0,0,0,0
137-9,2.6,1.2,4.3,3.4,0,0,.3,0,1.5,1.7,0,0,0,0
138-8.4,3.7,3.[illegible],2.1,1.8,2.7,0,.6,1,.4,0,0,0,0,0
139-7.8,3.3,1.1,3.9,3,2.1,0,.6,1,.5,0,.7,0,0,0
140-8,3.3,5.8,0,1.6,2.2,0,.6,.5,2,0,0,0,0,0
141-8,4.3,3.6,1.8,1.1,2.8,0,.6,1,.8,0,0,0,0,0
142-8,5.3,5.5,1.8,.8,0,1,.6,1,0,0,0,0,0,0
143-8,3,4.1,1,2.2,2.1,0,.6,.5,2.1,0,.4,0,0,0
144-7,3.4,2,1.9,0,0,1,.3,0,1.3,5.6,1.5,0,0,0
145-8,3.1,3,3.4,1.7,2.7,0,.6,1,.5,0,0,0,0,0
146-8,2.7,1.5,4.2,2.1,2.9,0,.6,1,.5,0,.5,0,0,0
147-8,2.4,2.1,5,4.1,0,0,.3,1,1.1,0,0,0,0,0
148-8,2.4,1.3,3.3,4.6,2.3,0,.3,1,.8,0,0,0,0,0
149-8.6,2.9,4.2,1.9,1.2,1.8,0,.6,1.4,1.4,0,0,0,0,0
150-8,3.9,2.2,3.6,.6,2.8,0,.4,1,1,0,.5,0,0,0
151-6.5,5,2.2,3.4,1.3,1.1,0,.3,1.7,0,.7,1.8,0,0,0
152-6.8,2.7,3.1,3.6,0,5.8,0,0,1,1,0,0,0,0,0
153-8,2.9,3.1,1.3,0,5.9,0,.9,1,.9,0,0,0,0,0
154-7.5,3.5,2.1,3,2,1.8,1.4,1.1,1,.6,0,0,0,0,0
155-8,2.4,1.1,1.5,1.1,2,4.8,.6,2,.2,0,.3,0,0,0
156-8,3.5,3.3,0,1,0,0,0,0,1.2,0,.3,6.7,0,0
157-8,4.6,0,0,.8,1.8,1,.6,1,2,0,0,4.2,0,0
158-8,4.5,0,0,3.6,0,2.1,.6,0,4.6,0,0,0,0,.6
159-8,4.2,0,0,0,0,2,0,0,0,0,0,0,0,9.8
160-0,1,0,0,0,0,0,0,0,0,0,0,0,7.8,2.5
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#THE ABOVE LISTING IS FOR THE COMMANDER OF SKYLAB II AL BEAN

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201-8,2.9,0,0,0,0,0,0,0,0,0,0,0,9.1,4
202-8,3.5,1.8,0,0,0,0,0,0,0,0,0,0,10.7
203-9.5,5.6,0,0,0,2.3,.5,.2,0,1.5,0,0,0,0,4.4
204-8,6.8,0,0,.6,.8,0,1,0,4.2,.3,0,0,2.3,0
205-8,6.9,0,0,0,8.2,0,.9,0,0,0,0,0,0,0
206-8,7.6,1,0,0,4.7,0,.5,0,1.2,1,0,0,0,0
207-8,6.6,5.8,0,0,1,0,0,0,1.2,.8,.6,0,0,0
208-8,5.2,.9,2,0,4.5,0,.3,0,2.5,0,.6,0,0,0
209-8,5.4,1.5,2.2,.8,.3,0,.3,.5,1.2,0,0,3.8,0,0
210-7.1,4.5,0,0,0,.2,0,0,.6,0,0,0,11.6,0,0
211-8.5,4.6,6.1,0,2.8,0,0,.5,0,.3,.6,0,.6,0,0
212-8,5,3.1,1.7,0,4,0,.5,.7,1,0,0,0,0,0
213-8,8,5.8,0,.3,.2,.8,.5,.4,0,0,0,0,0,0
214-8,7.2,1.8,0,0,.5,1.3,.3,1,3.4,0,.5,0,0,0
215-7,5.9,3.5,2.3,.4,.2,0,.5,1,1.4,0,1.8,0,0,0
216-8.7,4.5,0,3.1,1,3.6,0,.5,1,.6,0,1,0,0,0
217-8,6.2,4.7,0,0,2.2,0,.6,.5,.6,0,1.2,0,0,0
218-8,5.8,2.2,1.6,2.7,0,.5,1,0,0,2.2,0,0,0,0
219-8,5.8,5.9,0,0,2.4,0,.5,1,.4,0,0,0,0,0
220-8,4.9,8.8,0,0,.7,0,.6,1,0,0,0,0,0,0
221-8,4.5,6.9,0,.3,1.7,0,.5,1,.6,0,.5,0,0,0
222-8.8,5,4.5,0,.3,.2,0,0,1,.6,3.3,.3,0,0,0
223-8,4.6,6.3,0,1.2,1.7,0,.6,1,.3,0,.3,0,0,0
224-8,4.6,9,0,0,.2,0,.6,1,.6,0,0,0,0,0
225-8,3.7,6.1,0,1.8,2.5,0,.6,.5,.6,0,.2,0,0,0
226-8,4.6,2.3,0,0,5.5,0,.6,1,1,0,1,0,0,0
227-8.5,4,1,0,0,5.4,0,.5,.5,.3,0,3.8,0,0,0
228-8,3.4,1.1,0,.2,.2,0,0,0,.6,0,10.5,0,0,0
229-8,4.6,3.5,0,.5,4,0,.6,1,1.8,0,0,0,0,0
230-9.7,4.5,0,0,2.1,.9,0,0,1.1,1.7,.5,3.5,0,0,0
231-8,2.2,5.2,0,6.1,0,0,.3,1,0,0,1.2,0,0,0
232-8,4.3,2.2,0,0,4.7,0,.6,1,.9,0,2.3,0,0,0
233-7.8,3.4,5.4,1.3,0,3.1,0,.6,.7,1.3,0,.4,0,0,0
234-8,3.5,7.9,.3,.8,0,0,.6,1,.3,0,1.6,0,0,0
235-8,3.8,2.5,0,6,2.1,0,.5,0,1,0,0,0,0,0
236-8,3.3,4.6,1.8,1,1.6,0,.6,1,.6,0,1.5,0,0,0
237-9,2,3.3,2.3,2,.2,0,.6,1,2,1.6,0,0,0,0
238-7,4.3,4.6,0,3.1,3.5,0,.6,.5,.4,0,0,0,0,0
239-7.5,3.2,8.7,2,0,.2,0,.6,1,.8,0,0,0,0,0
240-8,4.5,5,.3,1,1.1,0,.6,1,.6,0,1.9,0,0,0
241-8,4.3,1.2,1.3,3.7,2.7,0,.6,1,1.2,0,0,0,0,0
242-8,4.2,3,1,2.8,2.1,0,.6,1,1.3,0,0,0,0,0
243-8,3.5,3.2,1.1,2,3.2,0,.6,1,1.4,0,0,0,0,0
244-6.7,4.8,3.2,1.4,2.8,0,0,.4,1,1.5,1.6,.6,0,0,0
245-7.8,3.4,5.8,1.2,0,3.4,0,.9,.7,.8,0,0,0,0,0
246-8,2.9,4.7,2.5,0,2.4,0,.3,1,2.2,0,0,0,0,0
247-8,3,5.8,3,.3,1.8,0,.9,0,1.2,0,0,0,0,0
248-8,4.1,5,2.7,0,1.8,0,.6,1,.4,0,.4,0,0,0
249-7.8,3.2,1.3,.3,3.2,4.2,0,.9,1.1,1.3,0,.7,0,0,0
250-8,2.9,2,2,0,5.7,0,.6,.5,2.3,0,0,0,0,0
251-6.5,6.1,2,1.5,.6,0,0,.5,.6,0,4,2.2,0,0,0
252-6.8,4.3,3,2.2,1.2,4.1,0,.6,1,.8,0,0,0,0,0
253-8,1.6,4.8,.9,.3,4.9,0,0,.5,2.5,0,.5,0,0,0
254-8,2.4,6,1.8,0,1.8,0,.9,1,2.1,0,0,0,0,0
255-8,2.3,5.3,.5,0,2.7,2,1.2,.9,0,0,1.1,0,0,0
256-8,2.9,1.2,1.5,1,2.7,0,.3,1,.6,0,0,4.8,0,0
257-8,4.2,0,0,.4,4.6,0,.3,0,.4,0,0,6.1,0,0
258-8,4.6,0,0,0,3,2,.3,.5,3.3,0,0,0,0,2.3
259-8,4.2,0,0,0,0,2,0,0,0,0,0,0,0,9.8
260-0,1,0,0,0,0,2,0,0,0,0,0,0,7.8,2.5
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#THE ABOVE LISTING IS FOR THE SCIENCE PILOT OF SKYLAB II OWEN GARRIOTT

ORIGINAL PAGE IS
OF POOR QUALITY

Table B-2 (Cont)

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SLP    11:31 JAN 31,'75

301-8,2.9,0,0,0,0,0,0,0,0,0,0,0,9.1,4
302-8,3.5,0,0,0,0,0,0,0,0,2,0,0,0,10.5
303-9.5,5.8,0,0,0,0,.5,0,0,.7,0,0,0,0,7.5
304-8,6.8,0,0,1.2,0,1.8,.3,.7,1.4,3.5,0,0,0,.3
305-8,6.6,0,3.2,1.5,3.6,0,.6,.5,0,0,0,0,0,0
306-8,5.9,0,2,3.8,3,0,.4,0,.9,0,0,0,0 ,0
307-8,6.7,0,4.3,1.3,0,0,.2,1.2,1.2,1.1,0,0,0,0
308-8,5.5,0,3,2,1.8,0,.3,1,2.2,0,.2,0,0,0
309-8,5.9,0,4,.3,0,0,.3,.5,0,0,0,5,0,0
310-7.1,4.5,0,0,0,0,0,0,.6,0,0,0,11.8,0,0
311-8.5,6.9,.8,.8,0,4.9,0,.7,.7,.7,0,0,0,0,0
312-8,7,0,2.8,0,3.4,0,.5,1,1.3,0,0,0,0,0
313-8,5.5,0,3.5,.5,1.2,.7,.4,1.1,3.1,0,0,0,0,0
314-8,6.1,1.1,1,3.3,0,0,.3,1,3.2,0,0,0,0,0
315-7,6.2,2.1,5,1.7,0,0,.3,1,.7,0,0,0,0,0
316-8.7,3.2,2.8,4.1,1.7,1.7,0,.5,.7,.6,0,0,0,0,0
317-8,5.8,3.6,0,4.4,0,0,.5,1,.7,0,0,0,0,0
318-8,5.3,2.6,0,3.2,2.6,0,.3,.5,1.5,0,0,0,0,0
319-8,5.8,1.5,0,4.6,2.1,1,.5,.5,0,0,0,0,0,0
320-8,4.6,2.2,0,4.8,2.2,0,.6,1.1,.5,0,0,0,0,0
321-8,3.5,3.1,0,0,7.5,0,.6,1,.3,0,0,0,0,0
322-8.2,4.2,4,0,1.2,0,0,0,0,3.7,2.7,0,0,0,0
323-8,3.4,3.2,0,4.2,1.7,1.5,.7,1,.3,0,0,0,0,0
324-8,3.3,3.3,.5,2.6,1.8,1.9,.6,1,.6,0,.4,0,0,0
325-8,4,5.1,0,4.6,0,0,.6,1.2,.5,0,0,0,0,0
326-8,3.8,3.2,0,3.6,3.8,0,.6,.5,.5,0,0,0,0,0
327-8.5,2.8,1.7,0,0,2.2,0,.5,1,2.5,0,0,4.8,0,0,
328-8,2.9,0,0,0,.3,0,.3,.5,0,0,0,12,0,0
329 8,3.9,2.1,0,1.1,5.6,0,.6,.8,1.9,0,0,0,0,0
330 9.7,3,4.3,0,1.9,0,0,.2,1,3.2,.7,0,0,0,0
331 8,3.8,2,0,3.3,3,0,.6,1,2.3,0,0,0,0,0
332 8,3.3,5.1,0,2.9,2.2,0,.4,1,.5,0,0,.6,0,0
333-8,4.1,2.1,0,5.5,2.9,0,.6,0,.3,0,.5,0,0,0
334 3,4.3,3.4,0,2.8,2.9,0,.6,1,1,0,0,0,0,0
335-8,3.1,6.7,0,.8,2.2,0,.6,1,1.6,0,0,0,0,0
336-6.3,4.2,7,2.8,.4,0,0,.6,1,1.1,0,.6,0,0,0
337-9,2.9,2.2,3.9,2.3,0,0,.6,1,1.5,.6,0,0,0,0
338-8.4,3.5,4,2,2.8,.3,0,.6,1,1.4,0,0,0,0,0
339-7.9,3,1.1,3.9,3.2,2,0,.6,1,.7,0,.6,0,0,0
340-8,3.9,1.7,0,3.9,2.2,0,.6,1,2.7,0,0,0,0,0
341-8,4.5,6.5,1.8,.4,0,0,.9,1.1,.8,0,0,0,0,0
342-8,4.5,1.2,1.8,1.1,1.8,.5,.6,1.1,3.1,0,.3,0,0,0
343-8,3.6,4.3,0,0,6.7,0,.4,1,0,0,0,0,0,0
344-7,3.4,6.2,1.9,2,.8,0,.5,1,1.2,0,0,0,0,0
345-8,3.8,1.5,3.4,0,5.2,0,.9,.6,.6,0,0,0,0,0
346-8,3.3,2.2,4.4,1.9,.7,0,.6,0,2.9,0,0,0,0,0
347-8,2,1,6.2,.3,2.3,0,.6,1,2.6,0,0,0,0,0
348-8,3.4,1,3.5,3.7,2.7,.4,.3,1,0,0,0,0,0,0
349-8,2.6,6,1.9,2.2,.5,0,.6,1,1.2,0,0,0,0,0
350-8,2.5,4.6,3.5,0,2.6,1,.6,1,.2,0,0,0,0,0
351-6,5.5,3,3.6,1.7,0,0,.3,1,.4,2.5,0,0,0,0
352-6.8,2.6,3,3.7,2.1,2.7,0,.3,1.5,1.3,0,0,0,0,0
353-8,3.7,2.2,1.5,2.3,4.7,0,.6,1,0,0,0,0,0,0
354-8,3.4,0,3.4,1.4,4.5,1,.6,1,.7,0,0,0,0,0
355-8,3.6,2.3,1.6,3.5,0,1.8,.9,1.5,.8,0,0,0,0,0
356-8,3.5,0,2,1.2,0,0,.5 ,.5,1.2,0,.3,6.8,0,0
357-8,4.5,0,2,0,2.1,0,.3,1,1.1,0,0,5,0,0
358-8,3.3,0,0,0,2.3,2,.3,0,6.6,0,0,0,0,1.5
359-8,4.2,0,0,0,0,2,.3,.5,0,0,0,0,0,9
360-0,1,0,0,0,0,2,0,0,0,0,0,0,7.8,2.5
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#THE ABOVE LISTING IS FOR THE PILOT OF SKYLAB II JACK LOUSMA

Table B-3 represents for each day of the Skylab II mission the 15 crew activities summarized for all three crewmen. This file was used to compute the statistical averages found in Section 3 of this volume. Other statistics as reported in Section 3 were similarly computed from the data files exhibited in Table B-2.

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Table B-3

SKYLAB II ACTIVITY SUMMARY

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	ACTIVITY (hr)														
1	8.0	2.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	9.1	4.0
2	8.0	3.7	.6	.0	.0	.0	.0	.0	.0	.0	1.3	.0	.0	.0	10.4
3	9.5	5.6	.0	.0	.0	.8	1.8	.2	.0	1.2	.0	.0	.0	.0	5.0
4	8.0	6.7	.0	.0	.6	.3	.5	.5	.5	2.9	2.9	.0	.0	.8	.3
5	8.0	6.5	.0	1.4	1.0	4.7	.9	.6	.2	.8	.0	.0	.0	.0	.0
6	8.0	6.6	.3	.8	2.6	2.6	.0	.5	.2	1.7	.7	.0	.0	.0	.0
7	8.0	6.5	1.9	2.6	1.9	.3	.0	.2	.8	.8	.6	.2	.0	.0	.0
8	8.0	5.4	.3	2.5	1.2	2.8	.0	.4	.7	2.5	.0	.3	.0	.0	.0
9	8.0	5.7	.5	3.5	.4	.1	.0	.3	.5	.4	.0	.0	4.6	.0	.0
10	7.1	4.6	.0	.0	.0	.1	.0	.0	.4	.0	.0	.0	1.8	.0	.0
11	8.5	6.4	2.3	.3	.9	3.[illegible]	.0	.0	.2	.9	.2	.0	.4	.0	.0
12	8.0	6.2	1.8	2.4	.5	2.5	.2	.4	.9	1.[illegible]	.0	.0	.0	.0	.0
13	8.0	6.1	1.9	2.3	.5	.8	1.0	.5	.8	2.0	.0	.0	.0	.0	.0
14	8.0	7.0	1.4	.3	1.1	.2	.8	.3	1.0	3.8	.0	.2	.0	.0	.0
15	7.0	6.5	2.3	4.3	.8	.1	.0	.4	1.0	1.0	.0	.6	.0	.0	.0
16	8.7	3.6	1.9	3.9	1.5	2.3	.0	.4	.9	.4	.0	.3	.0	.0	.0
17	8.0	6.4	3.1	.2	2.9	1.5	.0	.5	.7	.4	.0	.4	.0	.0	.0
18	8.0	6.0	3.9	.7	2.1	.9	.2	.6	.5	.5	.7	.0	.0	.0	.0
19	8.0	5.7	3.7	.2	3.0	1.5	.3	.5	.8	.3	.0	.0	.0	.0	.0
20	8.0	4.7	4.4	.0	3.1	1.8	.0	.5	.9	.6	.0	.0	.0	.0	.0
21	8.0	3.9	3.7	.0	2.5	3.5	.0	.6	1.0	.3	.0	.5	.0	.0	.0
22	8.5	5.1	4.4	.0	.6	.1	.2	.0	.3	2.0	2.7	.1	.0	.0	.0
23	8.0	4.2	4.2	.0	3.4	1.1	.5	.6	1.0	.9	.0	.1	.0	.0	.0
24	8.0	3.6	4.8	.2	1.0	1.3	3.4	.5	.7	.4	.0	.1	.0	.0	.0
25	8.0	4.4	4.6	.0	3.7	1.6	.0	.5	.9	.4	.0	.1	.0	.0	.0
26	8.0	3.6	3.5	.0	1.5	3.7	1.1	.6	.8	.5	.0	.6	.0	.0	.0
27	8.5	3.4	1.8	.0	.4	2.5	.7	.4	.8	1.8	.0	1.3	2.3	.0	.0
28	8.0	3.3	.8	.0	.1	.2	.3	.1	.2	.2	.0	3.5	7.5	.0	.0
29	8.0	4.4	3.0	.0	1.2	3.7	.0	.5	.9	1.9	.2	.1	.0	.0	.0
30	9.7	4.0	2.2	.0	2.2	.3	.0	.2	1.0	2.9	.4	1.2	.0	.0	.0
31	7.9	3.0	3.7	.0	5.1	1.5	.0	.4	1.0	1.0	.0	.4	.0	.0	.0
32	8.0	3.7	4.2	.0	1.7	3.0	.0	.4	.9	.7	.0	1.2	.2	.0	.0
33	7.9	3.5	3.6	.4	4.2	2.0	.0	.6	.6	.6	.0	.6	.0	.0	.0
34	8.0	3.7	3.8	.1	3.4	2.0	.3	.5	.9	.8	.0	.5	.0	.0	.0
35	8.0	3.2	3.8	.0	3.6	2.6	.6	.7	.7	.9	.0	.0	.0	.0	.0
36	7.4	3.6	4.3	2.6	1.5	1.4	.0	.4	.7	1.4	.0	.7	.0	.0	.0
37	9.0	2.5	2.2	3.5	2.6	.1	.0	.5	.7	1.7	1.3	.0	.0	.0	.0
38	7.9	3.8	4.0	1.4	2.6	2.2	.0	.6	.8	.7	.0	.0	.0	.0	.0
39	7.7	3.2	3.6	3.3	2.1	1.4	.0	.6	1.0	.7	.0	.4	.0	.0	.0
40	8.0	3.9	4.2	.1	2.2	1.8	.0	.6	.8	1.6	.0	.6	.0	.0	.0
41	8.0	4.4	3.8	1.6	1.7	1.8	.0	.7	1.0	.9	.0	.0	.0	.0	.0
42	8.0	4.7	3.2	1.5	1.6	1.3	.5	.6	1.0	1.5	.0	.1	.0	.0	.0
43	8.0	3.4	3.9	.7	1.4	4.0	.0	.5	.8	1.2	.0	.1	.0	.0	.0
44	6.9	3.9	3.8	1.7	1.6	.3	.3	.4	.7	1.3	2.4	.7	.0	.0	.0
45	7.9	3.4	3.4	2.7	.6	3.8	.0	.8	.8	.6	.0	.0	.0	.0	.0
46	8.0	3.0	2.8	3.7	1.3	2.0	.0	.5	.7	1.9	.0	.2	.0	.0	.0
47	8.0	2.5	3.0	4.7	1.6	1.4	.0	.6	.7	1.6	.0	.0	.0	.0	.0
48	8.0	3.3	2.4	3.2	2.8	2.3	.1	.4	1.0	.4	.0	.1	.0	.0	.0
49	8.1	2.9	3.8	1.4	2.2	2.2	.0	.7	1.2	1.3	.0	.2	.0	.0	.0
50	8.0	3.1	2.9	3.0	.2	3.7	.3	.5	.8	1.2	.0	.2	.0	.0	.0
51	6.3	5.5	2.4	2.8	1.2	.4	.0	.4	1.1	.1	2.4	1.3	.0	.0	.0
52	6.8	3.2	3.0	3.2	1.1	4.2	.0	.3	1.2	1.0	.0	.0	.0	.0	.0
53	8.0	2.7	3.4	1.2	.9	5.2	.0	.5	.8	1.[illegible]	.0	.2	.0	.0	.0
54	7.8	3.1	2.7	2.7	1.1	2.7	.8	.9	1.0	1.[illegible]	.0	.0	.0	.0	.0
55	8.0	2.8	2.9	1.2	1.5	1.6	2.9	.9	1.5	.3	.0	.5	.0	.0	.0
56	8.0	3.3	1.5	1.2	1.1	.9	.0	.3	.5	1.0	.0	.2	6.1	.0	.0
57	8.0	4.4	.0	.7	.4	2.8	.3	.4	.7	1.2	.0	.0	5.1	.0	.0
58	8.0	4.1	.0	.0	1.2	1.8	2.0	.4	.2	4.8	.0	.0	.0	.0	1.5
59	8.0	4.2	.0	.0	.0	.0	2.[illegible]	.1	.2	.0	.0	.0	.0	.0	9.5
60	.0	1.0	.0	.0	.0	.0	1.3	.0	.0	.0	.0	.0	.0	7.8	2.5

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Appendix C
ANALYSIS OF CREW SKILLS FOR THE MOSC STUDY

In developing the data base of research and applications requirements used in the MOSC Study, 103 potential payloads were examined. Of these, NASA discipline specialists recommended 20 payloads based upon the scientific and technological activities described in the Space Shuttle Payload Description Activity (SSPDA) reports. The MDAC study team recommended an additional 26 payloads which appeared to be candidates for extended missions on the basis of frequency and number of flights in the post-1984 time frame as described in the NASA mission model. In the space manufacturing area, four payloads were included as typical of those where high economic return and substantial savings potential would be offered by a significant increase in flight duration.

Further examination of the 50 payloads identified as candidates for MOSC consideration revealed that two payloads (LST Revisit, AS-01-R, and Large High-Energy Observatory Revisit, HE-11-R) were associated with revisits to unmanned orbiting observatories. These were eliminated from further design consideration at this stage of the study since they did not appear appropriate in determining configuration requirements. Two other payloads were classified as becoming operational flight support equipment by the time of the MOSC mission periods and therefore no longer candidates for research missions. These were the Free-Flying Teleoperator (LS-04-S) and the Integrated Real Time Contamination Monitor (ST-08-S).

The remaining 46 payloads were grouped into 19 combinations based on equipment commonality and operational requirements. Table C-1 summarizes the 19 payload combinations. The major operational and physical characteristics and requirements for each payload are also listed. The variance between the up and down payload weights is indicative of the amount of expendables (cryogenics, disposable fluids, gases, etc.) utilized during the conduct of

Table C-1

MOSC PAYLOAD COMBINATIONS

Payload	Description	Crew Manhours	Weight 1,000 lb (10^6 g) Up	Weight 1,000 lb (10^6 g) Down	Volume ft^3 (m^3)
C1	IR Astronomy	1,454	31 (14)	25 (11)	4,500 (135)
C2	UV Astronomy	3,845	24 (11)	14 (6)	1,100 (33)
C3	Solar Observations	4,187	15 (7)	14 (6)	1,000 (30)
C4	Space Sciences 1	2,070	17 (8)	15 (7)	2,700 (81)
C5	Space Sciences 2	1,608	16 (7)	12 (5)	2,200 (66)
C6	AMPS/Earth Science	3,280	24 (11)	14 (6)	1,900 (57)
C7	Space Technology	884	26 (21)	17 (8)	2,300 (69)
C8	Cloud Physics/Technology	882	15 (7)	13 (6)	2,000 (60)
C9	Earth Science 1	851	25 (11)	24 (11)	6,100 (183)
C10	Earth Science 2	690	26 (12)	26 (12)	6,000 (180)
C11	High-Energy Astronomy/Technology	1,118	20 (9)	20 (9)	1,200 (36)
C12	Life Science/Materials Technology 1	8,289	100 (45)	66 (30)	13,300 (400)
C13	Life Science/Materials Technology 2	4,039	81 (36)	60 (27)	10,600 (318)
C14	IR/UV Astronomy	1,427	45 (20)	17 (8)	2,000 (60)
C15	UV Astronomy, Advanced	585	24 (11)	16 (7)	1,000 (30)
C16	Cosmic Ray Lab	5,800	50 (23)	37 (17)	5,600 (168)
C17	LD Life Science Lab	23,200	39 (18)	34 (15)	2,600 (78)
C18	Advanced Technology	493	8 (4)	7 (3)	1,600 (48)
C19	Space Manufacturing	11,000	7 (3)	6 (3)	200 (6)

a flight or mission segment. The crew manhours listed represent a measure of the relative involvement of the crew in support of the activities necessary to perform the tasks required in the payload operation. The correlation between the 46 original payloads and the 19 MOSC payload groups is summarized in Table C-2. It should be noted, however, that all 50 of the original payloads were considered in analyzing the crew skill requirements.

The crew skill requirements for each of the original 50 payloads were defined in accordance with the standardized Spacelab categories(1) listed in Table C-3.

For purposes of the MOSC analysis the 23 skills in Table C-3 were reduced to 15 by combining Nos. 1 and 21, and 17 and 18, and omitting Nos. 6, 15, 16, 20, 22, and 23 since none of those latter skills were required by the payloads being examined.

The assignment of skills to payloads is summarized in Table C-4. It should be noted that only one payload (LS-10) had been identified by NASA discipline specialists as requiring the services of a medical doctor. For this sortie payload a medical doctor was described in the SSPDA documentation as being required in the role of an investigator for 12 hours per day. It will also be noted from Table C-4 that the highest demand skill was that of an electro-mechanical technician who was [illegible]uired in 29 of the 50 payloads. This high demand level suggests that this skill category be formally identified as a unique requirement in future selection and training.

Skill correlation matrices were then developed wherein the remaining 14 of the 15 skills were cross correlated based on whether or not they were required by each of the 50 payloads. This skill correlation matrix is presented in Table C-5. The statistics computed were the "phi" correlation coefficients for dichotomous variables.(2) The numerical entries which appear in Table C-5 represent a measure of the occasions when each pair of 15 skills are required (or not required) together. For "phi" coefficients approach 1.0 a particular pair could be considered well correlated or in other words occuring most

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(1) Table 4, page 19 of the ESSEX Corporation report prepared for MSFC entitled Role of Man in Flight Experiment Payloads, Volume 1: Results, dated August 1973.
(2) J.P. Guilford's Fundamental Statistics in Psychology and Education, McGraw-Hill, New York, 1956, Chapter 13.

Table C-2

PAYLOADS CONSIDERED FOR MOSC MISSIONS

SSPDA No.	Payload Description	Assigned to MOSC Combination(s)
Astronomy		
AS-01-S	1.5-m Cryogenically Cooled IR Telescope	C-1
AS-03-S	Deep-Sky UV Survey Telescope	C-2
AS-04-S	1-m Diffraction Limited UV Optical Telescope	C-2
AS-08-S	Multipurpose 0.5-m Telescope	C-2
AS-10-S	Advanced XUV Telescope	C-2
AS-13-S	Solar Variation Photometer	C-3
AS-15-S	3.0-m Ambient Temperature IR Telescope	C-1
AS-19-S	Selected Area Deep Sky Survey Telescope	C-11
AS-31-S	Combined AS-01, -03, -04, -05-S	C-14
AS-54-S	Combined UV Payload (AS-03-S, -04-S)	C-15
High Energy Astrophysics		
HE-14-S	Gamma Ray Pallet	C-11
HE-19-S	Low Energy X-ray Telescope	C-11
HE-X-S	Cosmic Ray Physics Lab FPE	C-16
Solar Physics		
SO-01-S	Dedicated Solar Sortie Mission	C-3
Atmospheric and Space Physics		
AP-06-S	Atmospheric, Magnetospheric, and Plasmas in Space (AMPS)	C-4, C-5, C-6
Earth Observations		
EO-01-S	Zero-g Cloud Physics Laboratory	C-8
EO-05-S	Shuttle Imaging Microwave System (SIMS)	C-9, C-10
EO-06-S	Scanning Spectroradiometer	C-10
EO-07-S	Active Optical Scatterometer	C-6
Earth and Ocean Physics		
OP-02-S	Multifrequency Radar Land Imagery	C-9
OP-03-S	Multifrequency Dual Polarized Microwave Radiometry	C-10
OP-04-S	Microwave Scatterometer	C-10
OP-05-S	Multispectral Scanning Imagery	C-6
OP-06-S	Combined Laser Experiment	C-9

Table C-2

PAYLOADS CONSIDERED FOR MOSC MISSIONS (Page 2 of 2)

SSPDA No.	Payload Description	Assigned to MOSC Combination(s)
Space Processing Applications		
SP-04-S	SPA No. 4 - General Purpose (Manned) (G+C)	C-12
SP-05-S	SPA No. 5 - Dedicated (Manned) (B+F+L+G+C)	C-12
SP-14-S	SPA No. 14 - Manned and Automated (B+G+C+FP+LP)	C-7
SP-15-S	SPA No. 15 - Automated Furnace/Levitation (FP+LP+CP)	C-13
SP-16-S	SPA No. 16 - Biological/General (Manned) (B+G+C)	C-12
SP-19-S	SPA No. 19 - Biological and Automated (B+C+FP+LP)	C-13
SP-X1-S	Production of Surface Acoustic Wave Components	C-19
SP-X2-S	Production of High Ductility Tungsten	C-19
SP-X3-S	Separation of Iso-enzymes	C-19
SP-X4-S	Furnace for Production of Semiconductor Silicon Ribbon	C-19
Life Sciences		
LS-09-S	Life Sciences Shuttle Laboratory	C-12, C-13
LS-10-S	Life Sciences Carry-on Laboratories	C-12, C-13
LS-X-S	Life Sciences Long Duration Laboratory	C-17
Space Technology		
ST-04-S	Wall-less Chemistry + Molecular Beam (Facility No. 1)	C-7
ST-05-S	Superfluid He + Particle/Drop Positioning (Facility No. 2)	C-7
ST-06-S	Fluid Physics + Heat Transfer (Facility No. 3)	C-11
ST-21-S	ATL Payload No. 2 (Module + Pallet)	C-8
ST-22-S	ATL Payload No. 3 (Module + Pallet)	C-8
ST-23-S	ATL Payload No. 5 (Pallet Only)	C-18
Communications and Navigation		
CN-02-S	Comm/Nav Shuttle Sortie Lab (4,000 lb)	C-4
CN-04-S	Terrestrial Sources of Noise and Interference	C-5
CN-06-S	Communication Relay Tests	C-5

Table C-3

SPACELAB CREW SKILL CLASSIFICATION

1. Biological Technician
2. Biochemist
3. Medical Doctor
4. Behavioral Scientist
5. Astronomer/Astrophysicist
6. Optical Scientist
7. Electromechanical/Optical Technician
8. Photo Technician/Cartographer
9. Geologist
10. Meteorologist
11. Oceanographer
12. Agronomist
13. Geographer
14. Electronics Engineer
15. Mechanical Engineer
16. Thermodynamicist
17. Metallurgist
18. Chemist
19. Physicist
20. General
21. Biologist
22. Biomedical Technician
23. Crewman

Table C-4

PAYLOAD SKILLS ASSIGNMENTS

SSPLA PAYLOAD	ELECTROMECHANICAL TECHNICIAN	ASTRONOMER	OCEANOGRAPHER	CHEMIST	GEOLOGIST	AGRONOMIST	ELECTRONICS ENGINEER	PHYSICIST	GEOGRAPHER	BEHAVIORAL SCIENTIST	PHOTO TECHNICIAN	METEOROLOGIST	BIOLOGIST	BIOCHEMIST	MEDICAL DOCTOR
AS01	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
AS03	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
AS04	1	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0
AS15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HEX	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
SU01	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
AP06	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
LSX	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0
ST21	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0
CN2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
ES1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
ES5	1	0	1	0	1	1	0	0	1	0	0	0	0	0	0
ES6	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0
ES7	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0
EP2	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0
EP3	1	0	1	0	0	0	0	0	1	0	0	1	0	0	0
EP4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
EP5	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0
EP6	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0
SP14	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
AS8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS10	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
AS13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS19	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
AS31	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
AS54	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
AS12	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
HE14	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
HE19	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
HE11	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
SP4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SP5	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SP15	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SP13	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SP19	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
LS4	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
LS9	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0
LS10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
ST4	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
ST5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
ST6	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
ST3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
ST22	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
ST23	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0
CN4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
CN5	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SP1X	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
SP2X	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
SP3X	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0
[illegible]	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0

1=REQUIRED SKILL 0=NOT REQUIRED

Table C-5

SKILL CORRELATION MATRIX

ROW 1 ELECTROMECHANICAL TECHNICIAN

1.00000	.16967	-.18127	-.09109	-.12156	-.12626
-.00701	-.24057	-.04780	.21499		
-.12626	.04436	-.12627	-.03309	-.16788	

ROW 2 ASTRONOMER

.16967	1.00000	-.27216	-.35044	-.20787	-.15755
-.25161	-.25161	-.18389	-.15755		
-.15755	-.15755	-.15755	-.12729	-.08909	

ROW 3 OCEANOGRAPHER

-.18127	-.27216	1.00000	-.24526	.76376	.57888
-.17609	-.17609	.67566	-.11026		
.34917	.34917	-.11026	-.08909	-.06235	

ROW 4 CHEMIST

-.09109	-.35044	-.24526	1.00000	-.18732	-.14197
.04319	.17815	-.16571	-.14197		
-.14198	-.14197	-.14197	.36324	-.08028	

ROW 5 GEOLOGIST

-.12156	-.20787	.76376	-.18732	1.00000	.75794
-.13449	-.13449	.63892	-.08422		
.19650	-.08422	-.08422	-.06804	-.04762	

ROW 6 AGRONOMIST

-.12626	-.15755	.57888	-.14197	.75794	1.00000
-.10194	-.10194	.85676	-.06383		
-.06383	-.06383	-.06383	-.05157	-.03609	

ROW 7 ELECTRONICS ENGINEER

-.00701	-.25161	-.17609	.04319	-.13449	-.10194
1.00000	-.16279	-.11898	.14077		
-.10194	-.10194	-.10194	-.08236	-.05764	

ROW 8 PHYSICIST

-.24057	-.25161	-.17609	.17815	-.13449	-.10194
-.16279	1.00000	-.11898	-.10194		
.14077	-.10194	.14077	-.08236	-.05764	

ROW 9 GEOGRAPHER

-.04780	-.18389	.67566	-.16571	.63892	.85676
-.11898	-.11898	1.00000	-.07450		
-.07450	.23592	-.07450	-.06019	-.04213	

ROW 10 BEHAVIORAL SCIENTIST

.21499	-.15755	-.11026	-.14197	-.08422	-.06383
.14077	-.10194	-.07450	1.00000		
-.06383	-.06383	.29078	-.05157	-.03609	

ROW 11 PHOTO TECHNICIAN

-.12626	-.15755	.34917	-.14198	.19650	-.06383
-.10194	.14077	-.07450	-.06383		
1.00000	.29078	-.06383	-.05157	-.03609	

ROW 12 METEOROLOGIST

.04436	-.15755	.34917	-.14197	-.08422	-.06383
-.10194	-.10194	.23592	-.06383		
.29078	1.00000	-.06383	-.05157	-.03609	

ROW 13 BIOLOGIST

-.12627	-.15755	-.11026	-.14197	-.08422	-.06383
-.10194	.14077	-.07450	.29078		
-.06383	-.06383	1.00000	-.05157	.56545	

ROW 14 BIOCHEMIST

-.03309	-.12729	-.08909	.36324	-.06804	-.05157
-.08236	-.08236	-.06019	-.05157		
-.05157	-.05157	-.05157	1.00000	-.02916	

ROW 15 MEDICAL DOCTOR

-.16788	-.08909	-.06235	-.08028	-.04762	-.03609
-.05764	-.05764	-.04213	-.03609		
-.03609	-.03609	.56545	-.02916	1.00000	

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frequently together. The matrix shows a 0.85676 correlation coefficient between the agronomist (row 6) and the geographer (row 9). Values near zero represent pairings that occur randomly without a significant pattern of being required together. For example the correlation coefficient between the electromechanical technician (row 1) and the meteorologist (row 12) is 0.04436. Negative values represent skill pairs that display a pattern of excluding one particular skill when a payload requires the other. Such an example is shown by a "phi" value of -0.35044 for both the astronomer (row 2) and chemist (row 4).

The correlation matrix was factor analyzed by the principal components solution[3] and six factors (or groups of skills) in addition to the electromechanical technician were identified. The computational methods of the principal component solution derives the characteristic equation of the correlation matrix and selects the most prominent eigenvectors (in this case the largest six) to represent the original 14 variables (rows) of the correlation matrix. The thereby derived "factor" matrix is subjected to the Kaiser varimax rotation procedure (4) in order to maximize the loadings (discrimination criteria) on the original variables rather than on the vectors. The 14 skills (excluding the electromechanical technician) identified in Table C-5 and their factor loadings appear in Table C-6. The interpretation of these factors appears in Table C-7. The assignments to the MOSC combination payloads of the combined skills specialists are indicated in Table C-8.

Since the IOC date for the MOSC Study is 1984, essentially eight years are available prior to IOC for the selection and training of the crew members. In this time period it is believed perfectly reasonable to cross train individuals in several related skill categories so that one appropriately cross-trained specialist can perform the tasks that would normally require several specialists in the conventional sense. As a starting point in implementing this concept, the seven skill factors identified above might provide a useful reference around which to structure the crew skill development process.

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(3) BMD Computer Programs Manual, W. J. Dixon editor, UCLA, 1964.
(4) Computer Program for Varimax Rotation, Kaiser, Educational and Psychological Measurement, Vol XIX, No. 3, 1959

Table C-6

ROTATED CREW SKILLS FACTOR MATRIX

	Factors					
	A	B	C	D	E	(F*) G
Astronomer	-0.29875	-0.16893	-0.29842	-0.47245	-0.43045	0.52809
Oceanographer	0.79470	-0.04661	0.46697	-0.07522	-0.06035	0.06067
Chemist	-0.14917	-0.14676	-0.15574	0.79214	0.27399	-0.03032
Geologist	0.89005	-0.04788	0.03328	-0.08773	0.05056	-0.05146
Agronomist	0.92629	-0.01843	-0.17525	-0.03141	-0.01986	0.03575
Electronics Engineer	-0.11795	-0.21941	-0.09524	0.03914	-0.10071	-0.77316
Physicist	-0.12316	0.03383	-0.01953	0.00741	0.90345	0.13869
Geographer	0.89008	-0.00803	0.04600	-0.00443	-0.12038	0.03666
Behavioral Scientist	-0.06854	0.23759	-0.05366	-0.19203	-0.06878	-0.65151
Photo Technician	0.02948	-0.07166	0.73682	-0.14466	0.29244	0.08247
Meteorologist	0.02798	0.00032	0.82080	0.02152	-0.22812	0.02619
Biologist	-0.05758	0.88676	-0.05513	-0.10015	0.24189	-0.12236
Biochemist	-0.05358	0.03693	-0.01259	0.78082	-0.21721	0.14365
Medical Doctor	-0.02790	0.84077	-0.01000	0.03588	-0.08187	0.07837

*This factor, which appears in the Factor Analysis solution for all 15 skills, disappears from the computations when the Electromechanical/Optical Technician skill is deleted from the input data.

Table C-7

CREW SKILLS COMBINATIONS

Factor	Job Title	No. of 19 Payload Combinations Using Skill	Equivalent Skill Categories from ESSEX Report	No. of Payloads Using ESSEX Skills
A	Earth Sciences Specialist	3	Geologist	5
			Oceanographer	8
			Agronomist	3
			Geographer	4
B	Life Sciences Specialist	3	Medical Doctor	1
			Behavioral Scientist	3
			Biologist	3
C	Meteorologist/ Photographer	4	Photo Technician	3
			Meteorologist	3
D	Materials Sciences Specialist	5	Biochemist	2
			Chemist	12
E	Physical Sciences Specialist	7	Electronics Engineer*	7
			Physicist	7
F	Engineering Technician	19	Electromechanical/ Optical Technician	29
G	Astronomical Sciences Specialist	6	Astronomer/ Astrophysicist	14

*The category of "Electronics Engineer" had no high positive loading in any factor (see Table C-6). Furthermore, as contrasted to the "Technician" who was required by 29 payloads the "Electronics Engineer" was required by only 7 (4 of which also required an Engineering Technician). These observations did not seem to warrant the establishment of a special skill category for the "Electronics Engineer." In view of the higher degree of theoretical understanding of physical phenomena required by the "Electronics Engineer" as compared to the "Engineering Technician," it was believed desirable to combine the Electronics Engineer category with that of the Physical Sciences Specialist.

Table C-8

MOSC PAYLOAD SKILLS REQUIREMENTS

Combined Skills Specialist	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19
	MOSC Payload																		
A - Earth Sciences						X			X	X									
B - Life Sciences												X	X				X		
C - Meteorologist/ Photographer						X		X	X	X									
D - Material Sciences							X				X	X	X						X
E - Physical Sciences				X	X	X	X	X								X		X	
F - Engineering Technician	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
G - Astronomical Sciences	X	X	X								X			X	X				

Of all the payloads where sufficiently detailed descriptive material was available, only one required a medical doctor per se. If it should be determined that a medical doctor is necessary, it is suggested that he be cross trained in other related areas to maximize his overall usefulness and effectiveness in meeting overall mission objectives. For example, with proper training he could not only function in the medical capacity but as a behavioral scientist and in the biological sciences as well.

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